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European Patent Office
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Publication number:

0 299 432
A2

(2)

EUROPEAN PATENT APPLICATION

(1) Application number: 88111142.1

(6) Int. CL⁶ G01R 15/07, G01R 31/28

(2) Date of filing: 12.07.88

(3) Priority: 13.07.87 JP 174534/87
13.07.87 JP 174535/87
13.07.87 JP 174536/87

(4) Date of publication of application:
18.01.89 Bulletin 89/03

(5) Designated Contracting States:
DE GB

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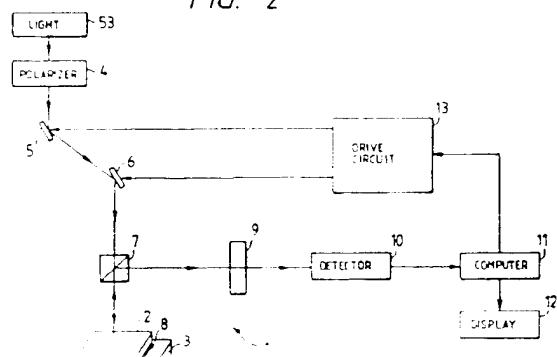
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(9) A voltage detecting device.

(10) A voltage detecting device for detecting voltages in an object under test including an electro-optic material covering a plurality of parts of the object under test; the refractive index of the electro-optic material being variable according to an applied voltage. A light source emits light through the electro-optic material toward the object under test and a detecting device receives an emergent light beam reflected from within the electro-optic material in order to detect voltages in the object. Further, a scanning device automatically scans the object under test with the light beam in order to detect voltages at a plurality of locations on the object.

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FIG. 2



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A VOLTAGE DETECTING DEVICE

BACKGROUND OF THE INVENTION

(Field of the Invention)

This invention relates to a voltage detecting device for detecting a voltage developed at a predetermined part of an object under measurement such as an integrated circuit, and more particularly to a voltage detecting device that utilizes the principle that the polarization of a light beam is changed by a voltage developed at a predetermined part of an object under test.

(Prior Art)

A variety of voltage detecting devices have been employed for detecting a voltage developed at a predetermined part of an object under measurement such as an integrated circuit. One example of a voltage detecting device of this type, which has been developed recently, detects the voltage of an object under test by utilizing the principle that the polarization of a light beam is changed by a voltage provided at a predetermined part of an object under measurement. A voltage detecting device of this type is disclosed in Japanese Unexamined Patent Application No.137317 87 filed on May 30, 1987.

An optical probe having an extremely small sectional area includes an electro-optic material that has a refractive index that is affected by the voltage of an object under test. A light beam with a predetermined polarization component is applied to the electro-optic material, and variations in polarization of the light beam caused by the change in refractive index of the electro-optic material is detected for measurement of a voltage developed at one part of the object under test. Such a device is shown in FIG. 1.

The voltage detecting device 50, as shown in FIG. 1, comprises an optical probe 52, a light source 53 for example, a laser diode, an optical fiber 51 for leading the output light beam of the light source 53 through a condenser lens 60 to the optical probe 52, and a detector 55 to which a reference light beam REF and an emergent light beam SG from the optical probe 52 are applied.

The optical probe 52 is formed from an electro-optic material 62 of an optically uniaxial crystal such as lithium tantalate (LiTaO₃), and has an end

portion 63 tapered like a truncated cone. A conductive electrode 64 is formed on the outer cylindrical wall of the optical probe 52. A reflecting mirror 65 of dielectric multi-layer film or metal film is bonded to the top of the end portion 63.

The optical probe 52 further includes a collimator 94, condenser lenses 95 and 96, a polarizer 54 for extracting a light beam having a predetermined polarization component out of the output light beams of the collimator 94, and a beam splitter 56 that divides the output light beam of the polarizer 54 into the reference light beam REF and an incident light beam IN and applies an emergent light beam from the electro-optic material 62 to an analyzer 57. The reference light beam REF and the output light beam SG are applied through the condenser lenses 95 and 96 and the optical fibers 58 and 59, respectively, to the detector 55.

In operation, the conductive electrode 64 of the optical probe 52 is held at ground potential. Under this condition, the end portion 63 of the optical probe 52 is placed near an object under test, for instance an integrated circuit (not shown). As a result, the refractive index of the end portion 63 of the electro-optic material 62 in the optical probe 52 is changed. More specifically, in the optically uniaxial crystal, the difference between the refractive index of an ordinary light beam and that of an extraordinary light beam in a plane perpendicular to the light-traveling direction is changed.

The output light beam of the light source 53 is applied through the condenser lens 60 and the optical fiber 51 to the collimator 94. The output light beam of the collimator 94 is applied to the polarizer 54, where it is converted into a light beam having a predetermined polarization component and an intensity of I. The output light beam of the polarizer 54 is applied through the beam splitter 56 to the electro-optic material 62 in the optical probe 52. Each of the reference light and the input light provided by the beam splitter 56 has an intensity of 1/2.

As described above, the refractive index of the end portion 63 of the electro-optic material 62 is affected by the voltage of the object. Therefore, the incident light beam IN applied to the electro-optic material 62 is changed in polarization with the refractive index of the end portion 63 of the electro-optic material 62, and reflected by the reflecting mirror 65. The reflected light beam is allowed to advance, as an emergent light beam, to the beam splitter 56. The polarization of the incident light beam IN changes in proportion to the difference in refractive index between the ordinary light beam and the extraordinary light beam (a light beam

passing through electro-optic material wherein the polarization has been changed due to the voltage of the test object) which is caused by the voltage of the test object and a value $2l$ (where l is the length of the end portion 63 of the electro-optic material 62).

The emergent light beam is applied to the analyzer 57 by the beam splitter 56. The intensity of the emergent light beam applied to the analyzer 57 is reduced to $1/4$ by the beam splitter 56. In the case where the analyzer 57 is designed to transmit only a light beam having a polarization component perpendicular to the polarization component of the polarizer 54, the intensity $1/4$ of the emergent light beam applied to the analyzer 57 is converted into $(1/4) \sin^2 [(\pi/2) \cdot V/V_0]$ (where V is the voltage of the object under test, and V_0 is the half-wave voltage by the analyzer).

The intensity $(1/4) \cdot \sin^2 [(\pi/2)V/V_0]$ of the emergent light beam SG changes with the refractive index of the end portion 63 of the electro-optic material 62 which changes with the voltage of the object. Therefore, the detector 55 can detect the voltage provided at the predetermined part of the test object such as an integrated circuit.

As described above, with the voltage detecting device 50 shown in FIG. 1, a voltage provided at a predetermined part of an object under test is detected from the change in refractive index of the end portion 63 of the electro-optic material 62 caused by placing the end portion 63 near the predetermined part of the object. Therefore, in the case where it is difficult to bring the optical probe into contact with a small part of an object under test, such as an integrated circuit, or where touching the test object with the optical probe may adversely affect the detection of the voltage, the voltage can be positively detected with the optical probe set apart from the object.

If a pulse light source such as a laser diode outputting a pulse light beam having an extremely small pulse width is employed as the light source 53 to detect high-speed voltage changes in the object under test when sampled at extremely short time intervals, or if a CW (Continuous-Wave) light source is employed as the light source 53 while a high-speed response detector such as a streak camera is used as the detector 55 so that high-speed voltage changes of the object may be measured with high time resolution, then high-speed voltage changes can be detected with high accuracy.

In the voltage detecting device 50, when in-

of an object, the operator must manually move the optical probe 52 to each of the points on the object. This manual movement of the optical probe is rather troublesome and time consuming.

Thus, the conventional voltage detecting device cannot be used to detect the voltages at a plurality of locations or parts of an object under test simultaneously. Also, it is physically difficult to miniaturize the optical probe, and it is difficult to improve the spatial resolution and thereby improve voltage measurement accuracy.

SUMMARY OF THE INVENTION

An object of the present invention is a voltage detecting device that can readily detect voltages at a plurality of points of an object under test.

Another object of the present invention is a voltage detecting device having improved spatial resolution to enable the detection of voltages in an object under test with high accuracy.

A further object of the present invention is a voltage detecting device that can simultaneously detect voltages at a plurality of two-dimensional parts of an object under test.

In order to achieve the foregoing and other objects, the voltage detecting device of the present invention comprises: an electro-optic material adapted to be disposed to cover a plurality of parts of the object under test, said electro-optic material having a refractive index that varies according to a voltage applied thereto; a light source for emitting a light beam through said electro-optic material toward the object under test; detecting means for receiving an emergent light beam reflected from within said electro-optic material for detecting voltages in the object under test; and scanning means for scanning said light beam emitted by said light source over a plurality of points on said electro-optic material so as to detect voltages at the plurality of parts of the object under test.

BRIEF DESCRIPTION OF THE DRAWINGS

The manner by which the above objects and other objects, features, and advantages of the present invention are attained will be fully apparent from the following detailed description when considered in light of the drawings attached.

FIG. 2 is an illustration of an embodiment of a voltage detecting device according to the present invention;

FIG. 3 is an explanatory diagram of an electro-optic material scanning method performed by the voltage detecting device of the present invention;

FIG. 4 is an illustration of a modification of the voltage-detecting device of the present invention;

FIG. 5 is an illustration of another embodiment of a voltage detecting device according to the present invention;

FIG. 6 is an illustration of further embodiment of a voltage detecting device according to the present invention which employs a pulse light source and a two-dimensional detector;

FIG. 7 is an illustration of a streak camera as used in the voltage detecting device of FIG. 6;

FIG. 8 is an illustration of a voltage-detecting device according to the present invention which displays the distribution of voltages provided at two-dimensional parts of an object under test in superposition with the wiring pattern of the object;

FIGS. 9(a) and 9(b) are explanatory diagrams showing the distributions of voltage detected at different sampling times as displayed by the voltage detecting device of FIG. 8;

FIG. 10 is an illustration of still further embodiment of a voltage detecting device according to the present invention;

FIG. 11 is an illustration of still further embodiment of a voltage detecting device according to the present invention;

FIG. 12 is an illustration of still further embodiment of a voltage detecting device according to the present invention; and

FIG. 13 is an illustration of still further embodiment of a voltage detecting device according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In a voltage detecting device provided according to the present invention, an electro-optic material may be placed to cover a plurality of parts or locations of an object under measurement to detect the voltages at those parts or locations. A light beam emitted from a light source is uniformly applied as parallel rays of light to parts or locations of the electro-optic material which correspond in position to the plurality of two-dimensional parts or locations of the object, and variations in the polarization of emergent rays of light from the two-dimensional parts of the electro-optic material are detected with a detector.

A voltage detecting device provided according to another aspect of the present invention comprises an observing light source for outputting a light beam different in wavelength from the above-described light source (pulse light source) for use in observing a wiring pattern of the object under test. Switching means apply one of the light beams outputted by the observing light source and the pulse light source to the electro-optic material and when the wiring pattern of the object is observed, phase compensating means adjusts the phase of the emergent rays of light so as to be different from that which is provided when the variations in polarization of the emergent rays of light are detected. A display means displays the voltages of the two-dimensional parts of the object which are measured from the variations in polarization of the emergent rays of light, in superposition with the wiring pattern of the object that is observed with the detector, and variable delay means shift the timing of application of the light beam from the pulse light source to the electro-optic material, for the purpose of measuring, in a sampling mode, the variation of the voltages provided at the two-dimensional parts of the object.

In the voltage detecting device of the present invention, the electro-optic material is first positioned to cover a plurality of parts of an object under test, the voltages of which should be detected, and the electro-optic material is scanned with a light beam in such a manner that the light beam is applied to the parts of the electro-optic material which correspond in position to the plurality of parts of the object. The electro-optic material scanning operation may be achieved by deflecting the light beam with movable mirrors or acousto-optical reflectors, or by moving the electro-optic material and the object. The voltages of the plurality of parts of the object can be readily detected from the variations in polarization of emergent light beams from the parts of the electro-optic material. Furthermore, the light beam can be applied to the electro-optic material while being focused thereon. Therefore, the device of the invention provides high spatial resolution, and can detect voltages with high accuracy.

The output light beam of the light source may also be applied by means of a micro-lens array, holographic lens, or spatial light modulator, as incident rays of light arranged in a desired pattern, to the parts of the electro-optic material which correspond in position to the predetermined parts of the object. In this operation, the refractive indexes of the parts of the electro-optic material have been changed by the voltages provided at the corresponding parts of the object. Therefore, the incident rays of light applied to the parts of the electro-optic material are changed in polarization

by the variations in refractive index of the parts of the electro-optic material, and are outputted, as emergent rays of light, from the electro-optic material. These emergent rays of light are applied to the detector, such as a two-dimensional photodetector or streak camera, and the voltages provided at the predetermined parts, such as two-dimensional parts, of the object can be simultaneously detected with the detector.

As a further aspect of the voltage detecting device provided according to the present invention, voltages provided at two-dimensional parts of the object under test are displayed in superposition with the wiring pattern of the object. For this purpose, in order to observe the wiring pattern of the object, a switching means is operated so that the output light beam of the observing light source is applied to the electro-optic material, and the phase of the emergent rays of light is adjusted for observation by the phase compensating means. As a result, the light beam from the observing light source is applied, as parallel rays of light, to the electro-optic material. The parallel rays of light reach the surface of the object through the electro-optic material. A dielectric multi-layer film mirror, which reflects the output light beam of the pulse light source more strongly than the output light beam of the observing light source, is formed on the bottom surface of the electro-optic material. Some of the parallel rays of light applied to the surface of the object are reflected by the wiring pattern of the object and outputted, as emergent rays of light, from the electro-optic material. The emergent rays of light from the electro-optic material are applied through the phase compensating means to the two-dimensional detector, where they are detected as visible image data of the wiring pattern of the object.

After the visible image data of the wiring pattern of the object has been detected in this manner, in order to detect the voltages of the two-dimensional parts of the object, the switching means is operated so that the output light beam of the pulse light source is applied to the electro-optic material, and the phase of the emergent rays of light is adjusted for voltage detection by the phase compensating means. In this case, the operation of the object must be in synchronization with the pulse light beam. As a result, the voltages of the two-dimensional parts of the object at one sampling time instant are detected. Thereafter, the display means displays on a display unit, or the like, the visible image of the object detected by the detector.

According to the present invention, the variation in the light intensity due to the variation in the

delay means, so that the voltages of the two-dimensional parts of the object are detected at the time instant that occurs somewhat after the preceding sampling time instant, and are displayed by the display means. Thus, the variations of the voltages at the two-dimensional parts of the object can be observed on the display screen in such a manner that they are superimposed on the wiring pattern of the object.

In the voltage detecting device 1, as shown in FIG. 2, an electro-optic material 2 is held near or in contact with an object 3 under test, e.g., an integrated circuit. The electro-optic material 2 is shaped like a plate or a prism, and its section is much larger than the section of the electro-optic material 62 in the optical probe 52 of the voltage detector 50 shown in FIG. 1. Thus, the material 2 is large enough to cover plurality of measurement points on the object 3. A reflecting mirror 8 of a metal or dielectric multi-layer film is formed on the bottom surface of the electro-optic material 2. In the case where the reflecting mirror 8 is a metal film, the measurement should be carried out with the reflecting mirror spaced away from the object 3 or with an insulating material (not shown) interposed between the reflecting mirror and the object 3.

The voltage detecting device 1 includes a light source 53, a polarizer 4 for extracting a light beam having a predetermined polarization component from the output light of the light source 53, two movable mirrors 5 and 6 for guiding the extracted polarized light beam, and a beam splitter 7 for applying the light beam to the electro-optic material 2, as an incident light beam, and for splitting an emergent light beam from the electro-optic material 2. The device also includes an analyzer 9 for extracting a light beam having a predetermined polarization component from the emergent light beam which has been reflected by the beam splitter 7 and changed in polarization, and a detector 10 to which an emergent light beam from the analyzer 9 is applied.

In the case where the light source 53 is a pulse light source, a photo-electric conversion element is utilized as the detector 10 to sample the intensity of the emergent light beam from the electro-optic material 2 to detect the voltage of the object under test. In the case where a CW light source is used as the light source 53, a high-speed response detector such as a streak camera for observing the intensity of the emergent light beam as a streak image is employed as the detector 10.

FIG. 3 shows a block diagram of a voltage detecting device 100. The device 100 includes a light source 102, a polarizer 104, a beam splitter 106, a movable mirror 108, a beam splitter 110, a movable mirror 112, a beam splitter 114, a reflecting mirror 116, a beam splitter 118, a movable mirror 120, a beam splitter 122, a reflecting mirror 124, a beam splitter 126, a movable mirror 128, a beam splitter 130, a reflecting mirror 132, a beam splitter 134, a movable mirror 136, a beam splitter 138, a reflecting mirror 140, a beam splitter 142, a movable mirror 144, a beam splitter 146, a reflecting mirror 148, a beam splitter 150, a movable mirror 152, a beam splitter 154, a reflecting mirror 156, a beam splitter 158, a movable mirror 160, a beam splitter 162, a reflecting mirror 164, a beam splitter 166, a movable mirror 168, a beam splitter 170, a reflecting mirror 172, a beam splitter 174, a movable mirror 176, a beam splitter 178, a reflecting mirror 180, a beam splitter 182, a movable mirror 184, a beam splitter 186, a reflecting mirror 188, a beam splitter 190, a movable mirror 192, a beam splitter 194, a reflecting mirror 196, a beam splitter 198, a movable mirror 200, a beam splitter 202, a reflecting mirror 204, a beam splitter 206, a movable mirror 208, a beam splitter 210, a reflecting mirror 212, a beam splitter 214, a movable mirror 216, a beam splitter 218, a reflecting mirror 220, a beam splitter 222, a movable mirror 224, a beam splitter 226, a reflecting mirror 228, a beam splitter 230, a movable mirror 232, a beam splitter 234, a reflecting mirror 236, a beam splitter 238, a movable mirror 240, a beam splitter 242, a reflecting mirror 244, a beam splitter 246, a movable mirror 248, a beam splitter 250, a reflecting mirror 252, a beam splitter 254, a movable mirror 256, a beam splitter 258, a reflecting mirror 260, a beam splitter 262, a movable mirror 264, a beam splitter 266, a reflecting mirror 268, a beam splitter 270, a movable mirror 272, a beam splitter 274, a reflecting mirror 276, a beam splitter 278, a movable mirror 280, a beam splitter 282, a reflecting mirror 284, a beam splitter 286, a movable mirror 288, a beam splitter 290, a reflecting mirror 292, a beam splitter 294, a movable mirror 296, a beam splitter 298, a reflecting mirror 300, a beam splitter 302, a movable mirror 304, a beam splitter 306, a reflecting mirror 308, a beam splitter 310, a movable mirror 312, a beam splitter 314, a reflecting mirror 316, a beam splitter 318, a movable mirror 320, a beam splitter 322, a reflecting mirror 324, a beam splitter 326, a movable mirror 328, a beam splitter 330, a reflecting mirror 332, a beam splitter 334, a movable mirror 336, a beam splitter 338, a reflecting mirror 340, a beam splitter 342, a movable mirror 344, a beam splitter 346, a reflecting mirror 348, a beam splitter 350, a movable mirror 352, a beam splitter 354, a reflecting mirror 356, a beam splitter 358, a movable mirror 360, a beam splitter 362, a reflecting mirror 364, a beam splitter 366, a movable mirror 368, a beam splitter 370, a reflecting mirror 372, a beam splitter 374, a movable mirror 376, a beam splitter 378, a reflecting mirror 380, a beam splitter 382, a movable mirror 384, a beam splitter 386, a reflecting mirror 388, a beam splitter 390, a movable mirror 392, a beam splitter 394, a reflecting mirror 396, a beam splitter 398, a movable mirror 400, a beam splitter 402, a reflecting mirror 404, a beam splitter 406, a movable mirror 408, a beam splitter 410, a reflecting mirror 412, a beam splitter 414, a movable mirror 416, a beam splitter 418, a reflecting mirror 420, a beam splitter 422, a movable mirror 424, a beam splitter 426, a reflecting mirror 428, a beam splitter 430, a movable mirror 432, a beam splitter 434, a reflecting mirror 436, a beam splitter 438, a movable mirror 440, a beam splitter 442, a reflecting mirror 444, a beam splitter 446, a movable mirror 448, a beam splitter 450, a reflecting mirror 452, a beam splitter 454, a movable mirror 456, a beam splitter 458, a reflecting mirror 460, a beam splitter 462, a movable mirror 464, a beam splitter 466, a reflecting mirror 468, a beam splitter 470, a movable mirror 472, a beam splitter 474, a reflecting mirror 476, a beam splitter 478, a movable mirror 480, a beam splitter 482, a reflecting mirror 484, a beam splitter 486, a movable mirror 488, a beam splitter 490, a reflecting mirror 492, a beam splitter 494, a movable mirror 496, a beam splitter 498, a reflecting mirror 500, a beam splitter 502, a movable mirror 504, a beam splitter 506, a reflecting mirror 508, a beam splitter 510, a movable mirror 512, a beam splitter 514, a reflecting mirror 516, a beam splitter 518, a movable mirror 520, a beam splitter 522, a reflecting mirror 524, a beam splitter 526, a movable mirror 528, a beam splitter 530, a reflecting mirror 532, a beam splitter 534, a movable mirror 536, a beam splitter 538, a reflecting mirror 540, a beam splitter 542, a movable mirror 544, a beam splitter 546, a reflecting mirror 548, a beam splitter 550, a movable mirror 552, a beam splitter 554, a reflecting mirror 556, a beam splitter 558, a movable mirror 560, a beam splitter 562, a reflecting mirror 564, a beam splitter 566, a movable mirror 568, a beam splitter 570, a reflecting mirror 572, a beam splitter 574, a movable mirror 576, a beam splitter 578, a reflecting mirror 580, a beam splitter 582, a movable mirror 584, a beam splitter 586, a reflecting mirror 588, a beam splitter 590, a movable mirror 592, a beam splitter 594, a reflecting mirror 596, a beam splitter 598, a movable mirror 600, a beam splitter 602, a reflecting mirror 604, a beam splitter 606, a movable mirror 608, a beam splitter 610, a reflecting mirror 612, a beam splitter 614, a movable mirror 616, a beam splitter 618, a reflecting mirror 620, a beam splitter 622, a movable mirror 624, a beam splitter 626, a reflecting mirror 628, a beam splitter 630, a movable mirror 632, a beam splitter 634, a reflecting mirror 636, a beam splitter 638, a movable mirror 640, a beam splitter 642, a reflecting mirror 644, a beam splitter 646, a movable mirror 648, a beam splitter 650, a reflecting mirror 652, a beam splitter 654, a movable mirror 656, a beam splitter 658, a reflecting mirror 660, a beam splitter 662, a movable mirror 664, a beam splitter 666, a reflecting mirror 668, a beam splitter 670, a movable mirror 672, a beam splitter 674, a reflecting mirror 676, a beam splitter 678, a movable mirror 680, a beam splitter 682, a reflecting mirror 684, a beam splitter 686, a movable mirror 688, a beam splitter 690, a reflecting mirror 692, a beam splitter 694, a movable mirror 696, a beam splitter 698, a reflecting mirror 700, a beam splitter 702, a movable mirror 704, a beam splitter 706, a reflecting mirror 708, a beam splitter 710, a movable mirror 712, a beam splitter 714, a reflecting mirror 716, a beam splitter 718, a movable mirror 720, a beam splitter 722, a reflecting mirror 724, a beam splitter 726, a movable mirror 728, a beam splitter 730, a reflecting mirror 732, a beam splitter 734, a movable mirror 736, a beam splitter 738, a reflecting mirror 740, a beam splitter 742, a movable mirror 744, a beam splitter 746, a reflecting mirror 748, a beam splitter 750, a movable mirror 752, a beam splitter 754, a reflecting mirror 756, a beam splitter 758, a movable mirror 760, a beam splitter 762, a reflecting mirror 764, a beam splitter 766, a movable mirror 768, a beam splitter 770, a reflecting mirror 772, a beam splitter 774, a movable mirror 776, a beam splitter 778, a reflecting mirror 780, a beam splitter 782, a movable mirror 784, a beam splitter 786, a reflecting mirror 788, a beam splitter 790, a movable mirror 792, a beam splitter 794, a reflecting mirror 796, a beam splitter 798, a movable mirror 800, a beam splitter 802, a reflecting mirror 804, a beam splitter 806, a movable mirror 808, a beam splitter 810, a reflecting mirror 812, a beam splitter 814, a movable mirror 816, a beam splitter 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splitter 998, a movable mirror 1000, a beam splitter 1002, a reflecting mirror 1004, a beam splitter 1006, a movable mirror 1008, a beam splitter 1010, a reflecting mirror 1012, a beam splitter 1014, a movable mirror 1016, a beam splitter 1018, a reflecting mirror 1020, a beam splitter 1022, a movable mirror 1024, a beam splitter 1026, a reflecting mirror 1028, a beam splitter 1030, a movable mirror 1032, a beam splitter 1034, a reflecting mirror 1036, a beam splitter 1038, a movable mirror 1040, a beam splitter 1042, a reflecting mirror 1044, a beam splitter 1046, a movable mirror 1048, a beam splitter 1050, a reflecting mirror 1052, a beam splitter 1054, a movable mirror 1056, a beam splitter 1058, a reflecting mirror 1060, a beam splitter 1062, a movable mirror 1064, a beam splitter 1066, a reflecting mirror 1068, a beam splitter 1070, a movable mirror 1072, a beam splitter 1074, a reflecting mirror 1076, a beam splitter 1078, a movable mirror 1080, a beam splitter 1082, a reflecting mirror 1084, a beam splitter 1086, a movable mirror 1088, a beam splitter 1090, a reflecting mirror 1092, a beam splitter 1094, a movable mirror 1096, a beam splitter 1098, a reflecting mirror 1100, a beam splitter 1102, a movable mirror 1104, a beam splitter 1106, a reflecting mirror 1108, a beam splitter 1110, a movable mirror 1112, a beam splitter 1114, a reflecting mirror 1116, a beam splitter 1118, a movable mirror 1120, a beam splitter 1122, a reflecting mirror 1124, a beam splitter 1126, a movable mirror 1128, a beam splitter 1130, a reflecting mirror 1132, a beam splitter 1134, a movable mirror 1136, a beam splitter 1138, a reflecting mirror 1140, a beam splitter 1142, a movable mirror 1144, a beam splitter 1146, a reflecting mirror 1148, a beam splitter 1150, a movable mirror 1152, a beam splitter 1154, a reflecting mirror 1156, a beam splitter 1158, a movable mirror 1160, a beam splitter 1162, a reflecting mirror 1164, a beam splitter 1166, a movable mirror 1168, a beam splitter 1170, a reflecting mirror 1172, a beam splitter 1174, a movable mirror 1176, a beam splitter 1178, a reflecting mirror 1180, a beam splitter 1182, a movable mirror 1184, a beam splitter 1186, a reflecting mirror 1188, a beam splitter 1190, a movable mirror 1192, a beam splitter 1194, a reflecting mirror 1196, a beam splitter 1198, a movable mirror 1200, a beam splitter 1202, a reflecting mirror 1204, a beam splitter 1206, a movable mirror 1208, a beam splitter 1210, a reflecting mirror 1212, a beam splitter 1214, a movable mirror 1216, a beam splitter 1218, a reflecting mirror 1220, a beam splitter 1222, a movable mirror 1224, a beam splitter 1226, a reflecting mirror 1228, a beam splitter 1230, a movable mirror 1232, a beam splitter 1234, a reflecting mirror 1236, a beam splitter 1238, a movable mirror 1240, a beam splitter 1242, a reflecting mirror 1244, a beam splitter 1246, a movable mirror 1248, a beam splitter 1250, a reflecting mirror 1252, a beam splitter 1254, a movable mirror 1256, a beam splitter 1258, a reflecting mirror 1260, a beam splitter 1262, a movable mirror 1264, a beam splitter 1266, a reflecting mirror 1268, a beam splitter 1270, a movable mirror 1272, a beam splitter 1274, a reflecting mirror 1276, a beam splitter 1278, a movable mirror 1280, a beam splitter 1282, a reflecting mirror 1284, a beam splitter 1286, a movable mirror 1288, a beam splitter 1290, a reflecting mirror 1292, a beam splitter 1294, a movable mirror 1296, a beam splitter 1298, a reflecting mirror 1300, a beam splitter 1302, a movable mirror 1304, a beam splitter 1306, a reflecting mirror 1308, a beam splitter 1310, a movable mirror 1312, a beam splitter 1314, a reflecting mirror 1316, a beam splitter 1318, a movable mirror 1320, a beam splitter 1322, a reflecting mirror 1324, a beam splitter 1326, a movable mirror 1328, a beam splitter 1330, a reflecting mirror 1332, a beam splitter 1334, a movable mirror 1336, a beam splitter 1338, a reflecting mirror 1340, a beam splitter 1342, a movable mirror 1344, a beam splitter 1346, a reflecting mirror 1348, a beam splitter 1350, a movable mirror 1352, a beam splitter 1354, a reflecting mirror 1356, a beam splitter 1358, a movable mirror 1360, a beam splitter 1362, a reflecting mirror 1364, a beam splitter 1366, a movable mirror 1368, a beam splitter 1370, a reflecting mirror 1372, a beam splitter 1374, a movable mirror 1376, a beam splitter 1378, a reflecting mirror 1380, a beam splitter 1382, a movable mirror 1384, a beam splitter 1386, a reflecting mirror 1388, a beam splitter 1390, a movable mirror 1392, a beam splitter 1394, a reflecting mirror 1396, a beam splitter 1398, a movable mirror 1400, a beam splitter 1402, a reflecting mirror 1404, a beam splitter 1406, a movable mirror 1408, a beam splitter 1410, a reflecting mirror 1412, a beam splitter 1414, a movable mirror 1416, a beam splitter 1418, a reflecting mirror 1420, a beam splitter 1422, a movable mirror 1424, a beam splitter 1426, a reflecting mirror 1428, a beam splitter 1430, a movable mirror 1432, a beam splitter 1434, a reflecting mirror 1436, a beam splitter 1438, a movable mirror 1440, a beam splitter 1442, a reflecting mirror 1444, a beam splitter 1446, a movable mirror 1448, a beam splitter 1450, a reflecting mirror 1452, a beam splitter 1454, a movable mirror 1456, a beam splitter 1458, a reflecting mirror 1460, a beam splitter 1462, a movable mirror 1464, a beam splitter 1466, a reflecting mirror 1468, a beam splitter 1470, a movable mirror 1472, a beam splitter 1474, a reflecting mirror 1476, a beam splitter 1478, a movable mirror 1480, a beam splitter 1482, a reflecting mirror 1484, a beam splitter 1486, a movable mirror 1488, a beam splitter 1490, a reflecting mirror 1492, a beam splitter 1494, a movable mirror 1496, a beam splitter 1498, a reflecting mirror 1500, a beam splitter 1502, a movable mirror 1504, a beam splitter 1506, a reflecting mirror 1508, a beam splitter 1510, a movable mirror 1512, a beam splitter 1514, a reflecting mirror 1516, a beam splitter 1518, a movable mirror 1520, a beam splitter 1522, a reflecting mirror 1524, a beam splitter 1526, a movable mirror 1528, a beam splitter 1530, a reflecting mirror 1532, a beam splitter 1534, a movable mirror 1536, a beam splitter 1538, a reflecting mirror 1540, a beam splitter 1542, a movable mirror 1544, a beam splitter 1546, a reflecting mirror 1548, a beam splitter 1550, a movable mirror 1552, a beam splitter 1554, a reflecting mirror 1556, a beam splitter 1558, a movable mirror 1560, a beam splitter 1562, a reflecting mirror 1564, a beam splitter 1566, a movable mirror 1568, a beam splitter 1570, a reflecting mirror 1572, a beam splitter 1574, a movable mirror 1576, a beam splitter 1578, a reflecting mirror 1580, a beam splitter 1582, a movable mirror 1584, a beam splitter 1586, a reflecting mirror 1588, a beam splitter 1590, a movable mirror 1592, a beam splitter 1594, a reflecting mirror 1596, a beam splitter 1598, a movable mirror 1600, a beam splitter 1598, a reflecting mirror 1600, a beam splitter 1596, a movable mirror 1594, a beam splitter 1592, a reflecting mirror 1590, a beam splitter 1588, a movable mirror 1586, a beam splitter 1584, a reflecting mirror 1582, a beam splitter 1580, a movable mirror 1578, a beam splitter 1576, a reflecting mirror 1574, a beam splitter 1572, a movable mirror 1570, a beam splitter 1568, a reflecting mirror 1566, a beam splitter 1564, a movable mirror 1562, a beam splitter 1560, a reflecting mirror 1558, a beam splitter 1556, a movable mirror 1554, a beam splitter 1552, a reflecting mirror 1550, a beam splitter 1548, a movable mirror 1546, a beam splitter 1544, a reflecting mirror 1542, a beam splitter 1540, a movable mirror 1538, a beam splitter 1536, a reflecting mirror 1534, a beam splitter 1532, a movable mirror 1530, a beam splitter 1528, a reflecting mirror 1526, a beam splitter 1524, a movable mirror 1522, a beam splitter 1520, a reflecting mirror 1518, a beam splitter 1516, a movable mirror 1514, a beam splitter 1512, a reflecting mirror 1510, a beam splitter 1508, a movable mirror 1506, a beam splitter 1504, a reflecting mirror 1502, a beam splitter 1500, a movable mirror 1498, a beam splitter 1496, a reflecting mirror 1494, a beam splitter 1492, a movable mirror 1490, a beam splitter 1488, a reflecting mirror 1486, a beam splitter 1484, a movable mirror 1482, a beam splitter 1480, a reflecting mirror 1478, a beam splitter 1476, a movable mirror 1474, a beam splitter 1472, a reflecting mirror 1470, a beam splitter 1468, a movable mirror 1466, a beam splitter 1464, a reflecting mirror 1462, a beam splitter 1460, a movable mirror 1458, a beam splitter 1456, a reflecting mirror 1454, a beam splitter 1452, a movable mirror 1450, a beam splitter 1448, a reflecting mirror 1446, a beam splitter 1444, a movable mirror 1442, a beam splitter 1440, a reflecting mirror 1438, a beam splitter 1436, a movable mirror 1434, a beam splitter 1432, a reflecting mirror 1430, a beam splitter 1428, a movable mirror 1426, a beam splitter 1424, a reflecting mirror 1422, a beam splitter 1420, a movable mirror 1418, a beam splitter 1416, a reflecting mirror 1414, a beam splitter 1412, a movable mirror 1410, a beam splitter 1408, a reflecting mirror 1406, a beam splitter 1404, a movable mirror 1402, a beam splitter 1400, a reflecting mirror 1398, a beam splitter 1396, a movable mirror 1394, a beam splitter 1392, a reflecting mirror 1390, a beam splitter 1388, a movable mirror 1386, a beam splitter 1384, a reflecting mirror 1382, a beam splitter 1380, a movable mirror 1378, a beam splitter 1376, a reflecting mirror 1374, a beam splitter 1372, a movable mirror 1370, a beam splitter 1368, a reflecting mirror 1366, a beam splitter 1364, a movable mirror 1362, a beam splitter 1360, a reflecting mirror 1358, a beam splitter 1356, a movable mirror 1354, a beam splitter 1352, a reflecting mirror 1350, a beam splitter 1348, a movable mirror 1346, a beam splitter 1344, a reflecting mirror 1342, a beam splitter 1340, a movable mirror 1338, a beam splitter 1336, a reflecting mirror 1334, a beam splitter 1332, a movable mirror 1330, a beam splitter 1328, a reflecting mirror 1326, a beam splitter 1324, a movable mirror 1322, a beam splitter 1320, a reflecting mirror 1318, a beam splitter 1316, a movable mirror 1314, a beam splitter 1312, a reflecting mirror 1310, a beam splitter 1308, a movable mirror 1306, a beam splitter 1304, a reflecting mirror 1302, a beam splitter 1300, a movable mirror 1298, a beam splitter 1296, a reflecting mirror 1294, a beam splitter 1292, a movable mirror 1290, a beam splitter 1288, a reflecting mirror 1286, a beam splitter 1284, a movable mirror 1282, a beam splitter 1280, a reflecting mirror 1278, a beam splitter 1276, a movable mirror 1274, a beam splitter 1272, a reflecting mirror 1270, a beam splitter 1268, a movable mirror 1266, a beam splitter 1264, a reflecting mirror 1262, a beam splitter 1260, a movable mirror 1258, a beam splitter 1256, a reflecting mirror 1254, a beam splitter 1252, a movable mirror 1250, a beam splitter 1248, a reflecting mirror 1246, a beam splitter 1244, a movable mirror 1242, a beam splitter 1240, a reflecting mirror 1238, a beam splitter 1236, a movable mirror 1234, a beam splitter 1232, a reflecting mirror 1230, a beam splitter 1228, a movable mirror 1226, a beam splitter 1224, a reflecting mirror 1222, a beam splitter 1220, a movable mirror 1218, a beam splitter 1216, a reflecting mirror 1214, a beam splitter 1212, a movable mirror 1210, a beam splitter 1208, a reflecting mirror 1206, a beam splitter 1204, a movable mirror 1202, a beam splitter 1200, a reflecting mirror 1198, a beam splitter 1196, a movable mirror 1194, a beam splitter 1192, a reflecting mirror 1190, a beam splitter 1188, a movable mirror 1186, a beam splitter 1184, a reflecting mirror 1182, a beam splitter 1180, a movable mirror 1178, a beam splitter 1176, a reflecting mirror 1174, a beam splitter 1172, a movable mirror 1170, a beam splitter 1168, a reflecting mirror 1166, a beam splitter 1164, a movable mirror 1162, a beam splitter 1160, a reflecting mirror 1158, a beam splitter 1156, a movable mirror 1154, a beam splitter 1152, a reflecting mirror 1150, a beam splitter 1148, a movable mirror 1146, a beam splitter 1144, a reflecting mirror 1142, a beam splitter 1140, a movable mirror 1138, a beam splitter 1136, a reflecting mirror 1134, a beam splitter 1132, a movable mirror 1130, a beam splitter 1128, a reflecting mirror 1126, a beam splitter 1124, a movable mirror 1122, a beam splitter 1120, a reflecting mirror 1118, a beam splitter 1116, a movable mirror 1114, a beam splitter 1112, a reflecting mirror 1110, a beam splitter 1108, a movable mirror 1106, a beam splitter 1104, a reflecting mirror 1102, a beam splitter 1100, a movable mirror 1098, a beam splitter 1096, a reflecting mirror 1094, a beam splitter 1092, a movable mirror 1090, a beam splitter 1088, a reflecting mirror 1086, a beam splitter 1084, a movable mirror 1082, a beam splitter 1080, a reflecting mirror 1078, a beam splitter 1076, a movable mirror 1074, a beam splitter 1072, a reflecting mirror 1070, a beam splitter 1068, a movable mirror 1066, a beam splitter 1064, a reflecting mirror 1062, a beam splitter 1060, a movable mirror 1058, a beam splitter 1056, a reflecting mirror 1054, a beam splitter 1052, a movable mirror 1050, a beam splitter 1048, a reflecting mirror 1046, a beam splitter 1044, a movable mirror 1042, a beam splitter 1040, a reflecting mirror 1038, a beam splitter 1036, a movable mirror 1034, a beam splitter 1032, a reflecting mirror 1030, a beam splitter 1028, a movable mirror 1026, a beam splitter 1024, a reflecting mirror 1022, a beam splitter 1020, a movable mirror 1018, a beam splitter 1016, a reflecting mirror 1014, a beam splitter 1012, a movable mirror 1010, a beam splitter 1008, a reflecting mirror 1006, a beam splitter 1004, a movable mirror 1002, a beam splitter 1000, a reflecting mirror 998, a beam splitter 996, a movable mirror 994, a beam splitter 992, a reflecting mirror 990, a beam splitter 988, a movable mirror 986, a beam splitter 984, a reflecting mirror 982, a beam splitter 980, a movable mirror 978, a beam splitter 976, areflecting mirror 974, a beam splitter 972, a movable mirror 970, a beam splitter 968, a reflecting mirror 966, a beam splitter 964, a movable mirror 962, a beam splitter 960, areflecting mirror 958, a beam splitter 956, a movable mirror 954, a beam splitter 952, areflecting mirror 950, a beam splitter 948, a movable mirror 946, a beam splitter 944, areflecting mirror 942, a beam splitter 940, a movable mirror 938, a beam splitter 936, areflecting mirror 934, a beam splitter 932, a movable mirror 930, a beam splitter 928, areflecting mirror 926, a beam splitter 924, a movable mirror 922, a beam splitter 920, areflecting mirror 918, a beam splitter 916, a movable mirror 914, a beam splitter 912, areflecting mirror 910, a beam splitter 908, a movable mirror 906, a beam splitter 904, areflecting mirror 902, a beam splitter 900, a movable mirror 898, a beam splitter 896, areflecting mirror 894, a beam splitter 892, a movable mirror 890, a beam splitter 888, areflecting mirror 886, a beam splitter 884, a movable mirror 882, a beam splitter 880, areflecting mirror 878, a beam splitter 876, a movable mirror 874, a beam splitter 872, areflecting mirror 870, a beam splitter 868, a movable mirror 866, a beam splitter 864, areflecting mirror 862, a beam splitter 860, a movable mirror 858, a beam splitter 856, areflecting mirror 854, a beam splitter 852, a movable mirror 850, a beam splitter 848, areflecting mirror 846, a beam splitter 844, a movable mirror 842, a beam splitter 840, areflecting mirror 838, a beam splitter 836, a movable mirror 834, a beam splitter 832, areflecting mirror 830, a beam splitter 828, a movable mirror 826, a beam splitter 824, areflecting mirror 822, a beam splitter 820, a movable mirror 818, a beam splitter 816, areflecting mirror 814, a beam splitter 812, a movable mirror 810, a beam splitter 808, areflecting mirror 806, a beam splitter 804, a movable mirror 802, a beam splitter 800, areflecting mirror 798, a beam splitter 796, a movable mirror 794, a beam splitter 792, areflecting mirror 790, a beam splitter 788, a movable mirror 786, a beam splitter 784, areflecting mirror 782, a beam splitter 780, a movable mirror 778

operation.

In the above-described voltage detecting device, the electro-optic material 2 is large enough to cover a plurality of measurement points (positions) on the object 3. In order to sequentially detect voltages provided at the plurality of measurement points on the object 3, the incident light beam is allowed to scan the electro-optic material 2 in the direction of the X-axis and in the direction of the Y-axis as shown in FIG. 3 while being focused on the object.

The movable mirror 5 is provided to scan the electro-optic material 2 in the direction of the X-axis, and the movable mirror 6 is provided to scan the electro-optic material 2 in the direction of the Y-axis. More specifically, when it is determined by the computer 11 that a voltage at a measurement point on the object 3 has been detected, the movable mirrors 5 and 6 are driven by a drive circuit 13 under control of the computer 11 so that the incident light beam scans the electro-optic material in the direction of the X-axis and in the direction of the Y-axis.

It is assumed that first the movable mirrors 5 and 6 are so positioned that the incident light beam is applied to a point (x_1, y_1) on the electro-optic material as shown in FIG. 2. The refractive index of the part of the electro-optic material 2 which corresponds to the point (x_1, y_1) is changed by the voltage of the object which is developed just below the point (x_1, y_1) . Therefore, the incident light beam applied to the point (x_1, y_1) is changed in polarization in accordance with the change in refractive index, and is then reflected by the reflecting mirror 8 so that it is applied, as an emergent light from the electro-optic material 2, to the beam splitter 7. The light beam is further applied through the analyzer 9 to the detector 10. The detector 10 detects a voltage provided at the part of the object 3 which is located just below the point (x_1, y_1) on the electro-optic material 2, and sends the voltage value to the computer 11. In the computer 11, the voltage value is processed and stored in a memory (not shown).

In order to detect a voltage provided at the part of the object 3 which is located just below the next scanning point on the electro-optic material 2, the computer 11 controls the drive circuit 13 to change the position of the movable mirror 5. As a result, the movable mirror 5 is moved in the direction of the X-axis so that the incident light beam is applied to the next scanning point on the electro-optic material 2, and the voltage detection operation is carried out in the same manner.

The movable mirror 5 is further repositioned in the direction of the X-axis until the incident light beam is applied to a point (x_n, y_1) on the electro-optic material 2. When a voltage developed at the

part of the object 3 which is located just below the point (x_n, y_1) is detected, the computer 11 controls the drive circuit 13 to change the positions of movable mirrors 5 and 6 so that the electro-optic material 2 is scanned in the direction of the X-axis at a position y_2 on the Y-axis. As a result, the movable mirror 6 is positioned to hold the incident light beam at the position y_2 and the movable mirror 5 is moved to scan the incident light beam at positions x_1 through x_n successively. The voltage detection operation is carried out in the same manner for the positions (x_1, y_2) through (x_n, y_2) .

The mirror 6 is eventually moved to hold the incident light beam at a position y_m on the Y-axis, and the mirror 5 scans the incident light beam through positions x_1 through x_n successively, so that voltages developed at the parts of the object which are located just below the points (x_1, y_m) through (x_n, y_m) on the electro-optic material 2 are detected. Thus, the voltages at a plurality of parts of the object can be detected. At the end of the voltage detection, the detected voltage levels are stored in the memory of the computer 11 to be later displayed on the display unit 12.

As is apparent from the above description, in the first example of the voltage detecting device of the invention, the electro-optic material 2 is fixedly held as it is scanned with the light beam so that the voltages developed at a number of parts of the object are detected.

FIG. 4 shows a modification of the voltage detecting device 1 shown in FIG. 2. In the voltage detecting device 20 shown in FIG. 4, as in the voltage detecting device 1 of FIG. 2, the electro-optic material 2 is stationary; however, it should be noted that the device 20 is different from the device 1 in that the device 20 employs acousto-optical deflectors 21 and 22 instead of the movable mirrors 5 and 6 (FIG. 2). The acousto-optical deflectors 21 and 22 are driven by a drive circuit 23, which is controlled by a computer 11, to deflect the light beam in the direction of the X-axis and in the direction of the Y-axis, respectively.

As in the voltage detecting device 1 shown in FIG. 2, the light beam is caused to scan the electro-optic material 2 in the direction of the X-axis and in the direction of the Y-axis while being focused thereon, so that voltages provided at a number of parts of the object 3 under test are detected.

FIG. 5 is an explanatory diagram showing the arrangement of a second example of the voltage detecting device according to the present invention. In FIG. 5, those components which have been previously described with reference to FIG. 2 or 4 are similarly numbered. In the voltage detecting device of FIG. 5, the output light beam of the light source 53 is not deflected; instead, the electro-

optic material 2 and the object 3 under test are moved in the direction of the X-axis and in the direction of the Y-axis so that the electro-optic material 2 is scanned by the light beam. That is, the voltage detecting device of FIG. 5 employs none of the movable mirrors 5 and 6 or the acousto-optical deflectors 21 and 22. Instead, the drive circuit 31, which is controlled by the computer 11, drives motor tables 32 and 33 which move the object 3 under test respectively in the direction of the X-axis and in the direction of the Y-axis.

In the voltage detecting device 30, the electro-optic material 2 and the object 3 are moved in the direction of the X-axis and in the direction of the Y-axis, so that voltages developed at a number of parts of the object 3 are detected successively. In the above-described voltage detecting device 30, both the electro-optic material and the object 3 are moved; however, the same effect can be obtained by moving only the object 3.

As described above, in the first or second embodiment of the voltage detecting device of the invention, the light beam is applied to the electro-optic material while being focused thereon, and the light beam is deflected by means of the movable mirrors 5 and 6 or the acousto-optical deflectors 21 and 22, or the electro-optic material 2 and the object 3 are moved without deflection of the light beam, so that the electro-optic material 2 is scanned with the light beam to detect the voltages at a plurality of parts of the object 3.

In the above-described voltage detecting devices, the electro-optic material is scanned, in its entirety, in the direction of the X-axis and in the direction of the Y-axis. However, in the case where the parts of an object 3 to be scanned to determine the voltages are predetermined, the following method may be employed: The positions of the parts of the object 3 are stored in memory in the computer 11 in advance, and the light beam is applied to the parts of the electro-optic material 2 which correspond to the stored parts of the object 3.

The voltages provided at a plurality of parts of the object can also be detected with higher accuracy by using the following method. The light beam from the light source 53, after being reflected from the beam splitter 7, is received, as a reference light beam, by a photo-detector and converted into a voltage. The voltage is stored in the computer 11 and compared with a signal provided by an emergent light beam from the electro-optic material to correct for fluctuations in intensity of the light source 53.

Device 1 includes electro-optic material 2 held close to or in contact with an object 3 under measurement. The electro-optic material 2 is large enough to cover a plurality of two-dimensional parts (or points) of the object 3. A reflecting mirror 8 made of a metal or a dielectric multilayer film is formed on the bottom surface of the electro-optic material 2.

The voltage detecting device 1 further comprises a pulse light source 104 for emitting a light beam with an extremely short pulse width, variable delay means 105 for variably delaying the output light beam of the pulse light source 104, an enlarging optical system 106 for two-dimensionally enlarging the light beam delayed by the variable delay means into parallel rays of light, and a polarizer 107 for extracting a predetermined polarization component from the parallel light beams. A beam splitter 110 applies the parallel rays of light to the electro-optic material 2 and applies a part of the light beam to an image-forming optical system 109 for voltage detection. Light reflected from the reflecting mirror 8 formed on the bottom surface of the electro-optic material 2 passes through the image forming optical system 109 to a phase compensator 111 for adjusting the phase of an emergent light beam from the image forming optical system 109. An analyzer 112 transmits only a light beam having a predetermined polarization component, which is selected out of the emergent light beam that has been phase-adjusted by the phase compensator 111. A detector 113 receives the emergent light beam from the analyzer 112.

As described above, the parallel rays of light applied to the electro-optic material 2 are two-dimensionally spread by means of the enlarging optical system 106. That is, they are applied to the electro-optic material 2 with uniform distribution, and the electro-optic material 2 is large enough to cover a plurality of two-dimensional parts of the object 3. The parallel rays of light applied to the electro-optic material 2 with uniform distribution are changed in polarization with changes in the refractive indexes of the two-dimensional parts of the electro-optic material 2, which correspond in position to the two-dimensional parts of the object 3. The reflected parallel rays of light emerge as rays of light (hereinafter referred to as "an emergent light beam", when applicable) from the electro-optic material 2. That is, the emergent rays of light from the electro-optic material 2 are equal in the area of distribution to the incident parallel rays of light (hereinafter referred to as "a parallel light

of the emergent light beams to allow the polarization component of the emergent light beam extracted by the analyzer 112 to form a predetermined angle with the polarization component of the parallel light beam extracted by the polarizer 107. For instance, the phase compensator 111 can make the polarization component of the emergent light beam extracted by the analyzer 112 parallel to or perpendicular to that of the parallel light beam extracted by the polarizer 107.

The detector 113 is a two-dimensional detector such as a CCD camera, photo-diode array or vidicon camera. The detector 113 detects the intensity of an emergent light beam from the analyzer 112 so that voltages provided at two-dimensional parts of an object 3 under test are simultaneously detected from the changes in refractive index of the corresponding parts of the electro-optic material 2.

In the case where the pulse light source 104 and the two-dimensional detector 113 are used in combination, voltages at two-dimensional parts of an object 3 under test must change periodically in synchronization with the light pulse. The light beam emitted from the pulse light source 104 is split by the beam splitter 110 into two parts: one of the two parts is applied to the variable delay circuit 105 for the purpose of sampling measurement, whereas the other is applied to a detector 118 where it is subjected to photo-electric conversion.

The output signal of the detector 118 is applied through a trigger circuit 119 to a drive circuit 129 so that the object 3 under test is operated periodically in synchronization with the light pulse. That is, voltages, which change repeatedly, are detected by sampling. This sampling operation is carried out by gradually delaying the output light beam of the pulse light source 104 with the variable delay means 105 that is controlled by a computer 114. The voltages at the two-dimensional parts of the object 3 are detected by the detector 113 with predetermined timing, and are then processed by the computer 114. The values of the voltages thus processed are stored in a memory (not shown). At the same time, the computer 114 controls the drive circuit 115 to drive the variable delay means 105 to delay the light beam from the pulse light source 104, where the sampling timing is somewhat shifted. Thus, the variations of the voltages at the two-dimensional parts of the object 3 under test can be detected.

In the voltage detecting device 1 thus organized, first the phase compensator 111 is adjusted so that the polarization component of the emergent rays of light extracted by the analyzer 112 is perpendicular to the polarization component of the parallel rays of light extracted by the polarizer 107. Therefore, when the emergent rays of light from the electro-optic material 2 are the same in po-

lariization as the parallel rays of light applied to the electro-optic material 2 (when no voltage is applied to the electro-optic material 2), no emergent rays of light will pass through the analyzer 112. After the phase compensator 111 has been adjusted in this manner, voltages at the two-dimensional parts of the object are detected.

As described above, the electro-optic material 2 is large enough to cover the two-dimensional parts of the object 3 under test. Therefore, the refractive indexes of the local parts of the electro-optic material 2 which correspond in position to the two-dimensional parts of the object 3, are changed by the voltages provided at the two-dimensional parts of the object 3. Accordingly, the parallel rays of light applied uniformly to the electro-optic material 2 are changed in polarization by the variations in refractive index of the two-dimensional parts of the electro-optic material 2 which correspond to the two-dimensional parts of the object 3 under test, and are outputted as emergent rays of light from the electro-optic material 2.

The emergent rays of light are applied through the beam splitter 110 and the image-forming optical system 109 to the phase compensator 111, where they are subjected to phase adjustment. The emergent rays of light thus processed are applied to the analyzer 112. The phase compensator 111 is adjusted so that the analyzer 112 transmits only the light beam whose polarization component is perpendicular to the polarization component of the polarizer 107. Therefore, the emergent rays of light applied to the analyzer 112 are made proportional in intensity to $\sin^2 [(\pi/2) \cdot V_1 / V_0]$ by the analyzer 112, and are then applied to the detector 113. In the expression, V_1 is the voltage developed in the two-dimensional position of a part of the object 3 under test, and V_0 is the half-wave voltage provided at the part.

As is apparent from the above description, the emergent rays of light are affected by the variations in refractive index of the two-dimensional parts of the electro-optic material 2 which are caused by the variations in voltage of the corresponding two-dimensional parts of the object 3 under test. Accordingly, voltages provided at two-dimensional parts of an object 3 under test can be simultaneously detected by the detector 113.

When the voltages of the two-dimensional parts of the object 3 are detected by the detector 113, the results of detection are stored in memory in the computer 114. In order to detect voltages with the following timing, the computer 114 controls the drive circuit 115 to drive the variable delay means 105, as a result of which the output light beam of the pulse light source 104 is delayed as required. That is, the sampling timing is somewhat shifted and the voltage detecting operation is carried out in

the same manner. The variations in voltage of the parts of the object 3 are measured in the sampling mode as described above. The results of measurement are stored in memory in the computer 114. When the measurement is carried out for a certain period of time, the computer 114 causes the display unit 116 to display the results of measurement. Thus, the voltage detecting operation of the device is accomplished.

In the voltage detecting device 1 of FIG. 6, the pulse light source 104 and the two-dimensional detector 113, such as a CCD camera, photo-diode array, or vidicon camera, are used in combination to detect the voltages by sampling which change periodically at two-dimensional parts of an object 3 under test. However, the voltage detecting device 1 cannot detect the voltage which does not change periodically.

FIG. 7 is an explanatory diagram outlining the arrangement of a part of a voltage detecting device that uses a streak camera to detect voltages at two-dimensional parts of an object under test.

In the voltage detecting device 120 of FIG. 7, instead of the two-dimensional detector 113 (FIG. 6) a bundle of optical fibers 121 is provided for guiding the emergent rays of light which have been passed through the phase compensator 111 and the analyzer 112. A streak camera 122 receives the guided emergent rays of light from the bundle of optical fibers 121. The device 120 of FIG. 7, may include a light source (not shown) such as a pulse light source, or a CW light source.

As is apparent from FIG. 7, the bundle of optical fibers transfers the two-dimensional arrangement of the emergent rays of light into a one-dimensional arrangement as the emergent rays of light are applied to a linear slit 123 of the streak camera 122.

In the voltage detecting device 120, after the phase compensator 111 is adjusted, as in the case of the voltage detecting device 1 of FIG. 6, the parallel rays of light are applied to the electro-optic material 2 by the pulse light source or CW light source, and the rays of light that emerge from the electro-optic material 2 and are passed through the phase compensator 111 and the analyzer 112 are applied to the bundle of optical fibers 121. As described above, the bundle of optical fibers 121 is arranged one-dimensionally (or in a line) at the slit 123 of the streak camera 122. Therefore, the voltage data of the two-dimensional parts of the object 3, being arranged one-dimensionally, are detected with high time resolution by the streak camera 122.

In the above-described embodiments, only voltages provided at two-dimensional parts of an object under test are detected, and displayed on the display unit 116. On the other hand, it would be convenient for the operator if the wiring pattern of an object 3 under test (such as an integrated circuit) is detected, and voltages provided at two-dimensional parts of the object were displayed in combination with the wiring pattern detected.

FIG. 8 is an explanatory diagram of a voltage detecting device that can display voltages at two-dimensional parts of an object in combination with the wiring thereof. In FIG. 8, parts corresponding functionally to those that have been already described with reference to FIG. 6 are designated by the same reference numerals.

In the voltage detecting device 30 of FIG. 8, in addition to the pulse light source 104, an observing light source 131 outputting a pulse light beam or CW light beam is provided to observe the wiring pattern of the object 3 under test. The light beam outputted by the observing light source 131 is different in wavelength from that outputted by the pulse light source; that is, the output light beam of the pulse light source 104 is reflected by a dielectric multi-layer film mirror 132 formed on the bottom surface of the electro-optic material 2. The output light beam of the observing light source 131 is transmitted through the dielectric multi-layer film mirror to the object 3.

A desired one of the light beams emitted from the light sources 104 and 131 is selected by switch 133 under control of the computer 114. In the observation of the wiring pattern of the object 3, the switch 133 selects the light beam outputted by the observing light source 131 so that it is applied through the electro-optic material 2 to the object 3 under test. In detection of voltages provided at two-dimensional parts (or points) of the object 3, the switch 133 selects the output light beam of the pulse light source 104 so that it is applied to the electro-optic material 2.

The phase compensator 111 is controlled by the computer 114. More specifically, in observing the wiring pattern of the object 3, the phase compensator 111 is adjusted so that the analyzer 112 transmits the emergent light beam having the same polarization component as that of the polarizer 107. In detection of voltages provided at two-dimensional parts of the object 3, the phase compensator 111 is adjusted so that the analyzer 112 transmits the emergent light beam whose polarization component is perpendicular to that of the polarizer 107.

parallel rays of light, to the surface of the object 3 under test, and adjusts the phase compensator 111 so that the analyzer 112 transmits the emergent light beam having the same polarization component as that of the polarizer 107.

As a result, the output light beam of the observing light source 131 is applied through the variable delay means 105, the enlarging optical system 106, the polarizer 107 and the beam splitter 110, as parallel rays of light, to the electro-optic material 2, and through the dielectric multi-layer film mirror 132 to the surface of the object 3. Depending on the wiring pattern on the surface of the object 3 and the material of the latter, some of the parallel rays of light are reflected and applied through the dielectric multi-layer film mirror 132, the electro-optic material 2, the beam splitter 110, the image-forming optical system 109 and the phase compensator 111, as emergent rays of light, to the analyzer 112. As described above, the phase compensator 111 is adjusted so that the analyzer 112 transmits the emergent light beam having the same polarization component as that of the polarizer 107. Therefore, the emergent rays of light applied to the analyzer 112 pass through the analyzer 112 and are applied to the two-dimensional detector 113, such as a CCD camera. The emergent light beam applied to the detector 113 has the visible image data of the wiring pattern on the surface of the object 3. Therefore, the emergent light beam is subjected to photo-electric conversion in the detector 113, to provide the visible image data of the wiring pattern. The visible image data is stored in a memory (not shown) in the computer 114.

After the visible image data of the wiring pattern of the object 3 has been stored as described above, the computer 114 initializes the variable delay means 105 and controls the switch 133 so that the output light beam of the pulse light source 104 is applied, as parallel rays of light, to the electro-optic material 2. The computer 114 further controls the phase compensator 111 so that the analyzer 112 transmits emergent rays of light having a polarization component perpendicular to that of the polarizer 107. Under this condition, voltages provided at two-dimensional parts of the object 3 under test are detected simultaneously. In this operation, the output light beam of the pulse light source 104 is applied, as parallel rays of light, to the electro-optic material 2. The parallel rays of light are reflected by the dielectric multi-layer film mirror 132 and are changed in polarization with the variations in refractive index of the electro-optic material 2, thus being applied, as emergent rays of light, to the phase compensator 111 and the analyzer 112. Only the emergent rays of light having the predetermined polarization component pass

through the analyzer 112 and are applied to the two-dimensional detector 113. In the detector 113, the voltages of the two-dimensional parts of the object 3 detected with the timing set by the variable delay means 105 are simultaneously detected by sampling. The results of voltage detection with one timing are supplied to the computer 114, where they are stored in the memory. Then, the results of detection of the voltages at the two-dimensional parts of the object 3 under test are displayed on the display unit 116 being superposed on the previously-stored visible image data of the wiring pattern of the object 3.

FIG. 9(a) shows the results of the detection of voltages provided at two-dimensional parts of an object 3 at one sampling timing which are displayed on the display unit 116 in a manner superposed on the wiring pattern of the object 3. More specifically, in FIG. 9(a), a two-dimensional voltage distribution as indicated at G1, G2 and G3 is shown superposed on the wiring pattern WF of the object 3.

After the results of detection of the voltages made with one sampling timing are displayed in superposition on the wiring pattern, the computer 114 controls the drive circuit 115 to drive the variable delay means 105, so that the delay of the output light beam of the pulse light source 104 is changed, and the sampling timing is somewhat changed. Under this condition, the voltage detecting operation and the display of the results of detection of voltages are carried out in the same manner.

FIG. 9(b) shows the voltages of the two-dimensional parts of the object 3 which are detected with a slightly shifted sampling timing which are displayed by being superposed on the wiring pattern of the object 3. In other words, the voltage distributions indicated at G1, G2 and G3 in FIG. 9(a) are changed to G1', G2' and G3', respectively, in FIG. 9(b).

As is apparent from FIGS. 9(a) and 9(b) with the voltage detecting device 30 of FIG. 8, the variation of the voltage distribution over the wiring pattern of the object 3 can be visually detected by means of the display unit 116. In this manner, the results of detection of the voltages provided at two-dimensional parts of an object under test can be read with ease.

FIG. 10 is an explanatory diagram showing yet another embodiment of a voltage detecting device according to the present invention. In the voltage detecting device 1 of FIG. 10, an electro-optic material 2 is also fixedly positioned in such a manner that it is close to or in contact with an object 3 under measurement. As in the other embodiments, the electro-optic material 2 is large enough to cover a plurality of two-dimensional

parts of the object 3, and a reflecting mirror 8 of metal or dielectric multi-layer film is formed on the bottom surface of the electro-optic material 2.

The voltage detecting device 1 comprises a polarizer 204, for extracting a predetermined polarization component from a light beam BM emitted by a light source (not shown), and a micro-lens array 205 for dividing the light beam, which has the polarization component extracted by the polarizer, into a number of rays of light EM_{ij} arranged in matrix form (a checked pattern). A beam splitter 206 is provided to apply the number of rays of light EM_{ij} to the electro-optic material 2 and to reflect a number of emergent rays of light SG_{ij} arranged in matrix form, which are outputted from the electro-optic material 2 after being reflected from the reflecting mirror 8 formed on the bottom surface of the electro-optic material 2. The emergent rays of light SG_{ij} are transmitted toward an analyzer 207 that transmits only the emergent rays of light SG_{ij} having a predetermined polarization component. A detector 209 receives the emergent rays of light that pass through the analyzer 207.

The micro-lens array 205 is made up of a plurality of first rod lenses 210 arranged in a first direction, and a plurality of second rod lenses 211 arranged in a second direction perpendicular to the first direction and laid over the first rod lenses 210 such that a light beam applied thereto is divided into rays of light arranged in matrix form.

The detector 209 comprises a two-dimensional photo-detector such as a CCD camera, photo-diode array, or vidicon camera, or a high-speed response detector such as a streak camera.

In the voltage detecting device 1 of FIG. 10, the electro-optic material 2 is large enough to cover a plurality of two-dimensional parts of the object 3 under test, so that the two-dimensional parts of the electro-optic material which correspond in position to the two-dimensional parts of the object 3 are changed in polarization by voltages provided at corresponding two-dimensional parts of the object 3. Accordingly, when the rays of light EM_{ij} arranged in matrix form and having the predetermined polarization component pass through the parts of the electro-optic material 2, they are changed in polarization by the variations in refractive index of the parts of the electro-optic material 2 and are outputted, as emergent rays of light, from the electro-optic material 2. The emergent rays of light are applied to the analyzer 207 by means of the beam splitter 206. In the case where the analyzer 207 is designed to transmit only a

and are then applied to the detector 209. In the expression, V_{ij} is the voltage provided at any one of the two-dimensional matrix parts of the object 3 under test, and V_{1/2} is the half-wave voltage.

As is apparent from the above description, the emergent rays of light depend in intensity on the variations in refractive index of the matrix parts of the electro-optic material 2 which are caused by the voltages provided at the corresponding matrix parts of the object 3. Therefore, voltages provided at two-dimensional matrix parts of all the two-dimensional parts (points) of an object under test such as an integrated circuit can be detected simultaneously.

In the above-described example of the voltage detecting device according to the present invention, the micro-lens array 205 is used to form a number of rays of light EM_{ij} arranged in matrix form, and the rays of light thus formed are applied to the electro-optic material 2 to detect the voltages provided at the two-dimensional matrix parts of the object. In some instances, it is desirable that voltages provided at predetermined two-dimensional parts of an object 3 under test be detected.

FIGS. 11, 12 and 13 are explanatory diagrams showing three additional embodiments of the voltage detecting device according to the present invention which can detect voltages provided at given two-dimensional parts of an object under measurement. In FIGS. 11, 12 and 13, parts corresponding functionally to those which have been described with reference to FIG. 10 are designated by the same reference numerals or characters.

In the voltage detecting device 1 of FIG. 11, a slate-shaped mask 212 is disposed between the micro-lens array 205 and the beam splitter 206, the mask 212 has a number of holes 213 arranged in matrix form. Some of the holes 213 are closed to provide a desired light beam pattern. With the mask 212, only desired rays of light are applied to the electro-optic material 2 to detect voltages at desired two-dimensional parts of the object 3.

In the voltage detecting device 20 of FIG. 12, instead of the micro-lens array 205, a holographic lens 221 is used to focus the light beam on only predetermined two-dimensional parts (i₀, j₀), (i₁, j₀), (i₀, j₁) and (i₁, j₁) of the electro-optic material 2. If, in this connection, the distance between the holographic lens 221 and the electro-optic material 2 is increased, and the distances between the electro-optic material 2 and the beam splitter 206 and the detector 209 are decreased, then a satisfactory resolution may be obtained.

HG4 according to its hologram record. These reproduced images HG1 through HG4 are applied through the beam splitter 206, as incident rays of light, to predetermined two-dimensional part (i₁, j₁), (i₁, j₂), (i₂, j₁) and (i₂, j₂) of the electro-optic material, respectively. The reproduced images, namely, rays of light HG₁ through HG₄ applied to those two-dimensional parts of the electro-optic material 2 are changed in polarization by the refractive indexes of the two-dimensional parts of the electro-optic material 2 which are changed by voltages provided at the two-dimensional parts of the object 3 that are just below the two-dimensional parts of the electro-optic material 2. The incident rays of light HG₁ through HG₄, which have been changed in polarization, are outputted as emergent rays SG₁ through SG₄ from the electro-optic material 2. These emergent rays of light SG₁ through SG₄ are applied through an image-forming optical system 222 and the analyzer 7 to the detector 209 by means of the beam splitter 206, whereby the voltages at the two-dimensional part of the object 3 can be detected. By changing the hologram record of the holographic lens 221, voltages at desired two-dimensional parts of the object 3 can be readily detected.

In the voltage detecting device 230 of FIG. 13, instead of the micro-lens array 205 a spatial light modulator 231 is used.

The spatial optical modulator 231 is so designated that when an input image IG is applied to its input surface 232, a light beam applied to its output surface is outputted, in a pattern corresponding to the input image IG, from the output surface 233. In other words, when a light beam BM having a predetermined polarization component, which has been extracted by a polarizer 234, is applied through a beam splitter 235 to the output surface 233 of the spatial light modulator 231, the light beam BM is reflected, in a pattern corresponding to the input image IG, from the spatial optical modulator 231. The light beam thus reflected is applied through the beam splitter 235 to the polarizer 204, where a predetermined polarization component is extracted. The light beam thus treated is applied through a reducing optical system 236 and the beam splitter 206 to the electro-optic material 2.

When, in the voltage detecting device 30 thus organized, an input image IG consisting of image parts IG₁ through IG₆ is applied to the input surface 232 of the spatial light modulator 231, then the light beam is reflected, in a pattern corresponding to the image parts IG₁ through IG₆, from the output surface 233 of the spatial optical modulator 231, and applied, as incident rays of light, to the corresponding two-dimensional parts P₁ through P₆ of the electro-optic material. As described above,

when the light beam is applied to the polarizer 204, the predetermined polarization component is extracted. The incident rays of light are changed in polarization by the refractive indexes of the two-dimensional parts P₁ through P₆ by the variation in refractive index of the two-dimensional parts P₁ through P₆ of the electro-optic material 2 which are caused by the voltages provided at the two-dimensional parts P₁ through P₆ of the electro-optic material 2, and are then outputted as emergent rays of light from the electro-optic material 2. The emergent rays of light from the electro-optic material 2 are applied through the analyzer 7 to the detector 209 by means of the beam splitter 206, so that the voltages at the two-dimensional parts of the object 3 which correspond to the parts IG₁ through IG₆ of the input image IG, respectively, can be detected. Since the pattern of the input image IG can be changed freely, voltages at given two-dimensional parts of the object 3 can be detected.

In the above-described additional embodiments of the voltage detecting device of the present invention, the incident rays of light can be applied to selected two-dimensional parts of the electro-optic material 2, and voltages provided at the object 3 can be detected simultaneously.

Claims

1. A voltage detecting device for detecting voltages in an object to be measured, comprising:
an electro-optic material to be disposed to cover a plurality of positions of the object to be measured, and having a refractive index which varies according to a voltage applied thereto;
a light source for emitting a light beam through said electro-optic material toward the object to be measured;
scanning means for scanning said light beam emitted by said light source over a plurality of parts on said electro-optic material corresponding to said plurality of positions of the object to be measured;
detecting means for receiving an emergent light beam which emerges from said electro-optic material to detect voltages at said plurality of positions of the object to be measured according to changes in polarization of said emergent light beam caused by changes in said refractive index of said electro-optic material.
2. A voltage detecting device according to claim 1, wherein said scanning means includes deflecting means for deflecting said light beam emitted by said light source across said electro-optic material.

3. A voltage detecting device according to claim 1, wherein said scanning means includes moving means for moving said object to be measured and said electro-optic material in a plurality of directions.

4. A voltage detecting device according to claim 1, wherein said light beam directed to said electro-optic material is focused therein.

5. A voltage detecting device according to claim 1, wherein said detecting means is a high-speed response detector.

6. A voltage detecting device according to claim 5, wherein said high-speed response detector is a streak camera.

7. A voltage detecting device for detecting voltages in an object to be measured, comprising: an electro-optic material to be disposed to cover a plurality of two-dimensional positions of the object to be measured and having a refractive index that varies according to a voltage applied thereto; means for emitting a parallel light beam toward each of a plurality of two-dimensional parts on said electro-optic material corresponding to said plurality of two-dimensional positions of the object; and detecting means for detecting changes in polarization of a emergent light beam emerging from said plurality of two-dimensional portions of said electro-optic material.

8. A voltage detecting device as claimed in claim 7, wherein said emitting means includes a pulse light source short in pulse width and said detecting means is formed by a two-dimensional photo-electric conversion detector for sampling detecting changes in voltage at said plurality of two-dimensional position of the object by shifting a timing of application of said light beam to said electro-optic material.

9. A voltage detecting device as claimed in claim 7, in which said emitting means is formed by one of a CW light source and a pulsed light source and said detecting means is formed by a high-speed response detector, and further comprising: a bundle of optical fibers arranged to convert a two-dimensional arrangement of said emergent light beam into a one-dimensional arrangement thereof to guide said emergent light beam into said high-speed response detector.

10. A voltage detecting device as claimed in claim 9, in which said high-speed response detector is a streak camera.

11. A voltage detecting device as claimed in claim 7, further comprising:

a) a phase compensator means for compensating

b) two-dimensional positions of the object to be measured and having a refractive index that varies according to a voltage applied thereto;

c) a pulse light source means for emitting a pulse light beam having a short pulse width in parallel through said electro-optic material toward the object to be measured;

d) an observing light source means for emitting a light beam different in wavelength from said pulse light beam through said electro-optic material toward the object to be measured for observation of a wiring pattern in the object to be measured;

e) switching means for selecting one of said pulse light beam and said light beam to be applied to said electro-optic material;

f) detecting means which receives an emergent light beam which emerges from said electro-optic material for detecting voltages in the object to be measured based on changes in polarization of said emergent light beam caused by changes in said refractive index of said electro-optic material, and for detecting the wiring pattern in the object to be measured;

g) a phase compensator means for adjusting the phase of said emergent light beam to a different phase between for detection of changes in polarization of said emergent light beam and for observation of the wiring pattern;

h) display means for displaying the voltages at said plurality of two-dimensional positions of the object detected by said detecting means together with the wiring pattern in the object detected by said detecting means, the former being superimposed on the latter; and

i) variable delay means for shifting emitting timing of said pulse light beam to said electro-optic material for sampling-measurement of changes in voltages at said plurality of two-dimensional positions of the object to be measured.

12. A voltage detecting device as claimed in claim 11, further comprising a dielectric multi-layer film mirror formed on the bottom surface of said electro-optic material for transmitting said light beam from said observing light source means and reflecting said pulse light beam from said pulse light source means.

13. A voltage detecting device as claimed in claim 12, wherein said phase compensator means adjusts the phase of said emergent light beam so as to apply said emergent light beam to said detecting means as it is when the wiring pattern is observed, and to extract said emergent light beam which is subjected to changes in polarization from

15. A voltage detecting device for detecting voltages in an object to be measured, comprising:
an electro-optic material disposed to cover a plurality of positions of the object to be measured, and
having a refractive index that varies according to a voltage applied thereto;
light source means for emitting a light beam through said electro-optic material toward the object to be measured;
optical means for dividing said light beam into a plurality of incident rays of light arranged in a predetermined pattern, said plurality of incident rays of light being applied to specific portions of said electro-optic material corresponding to specific positions of the object to be measured, and
detecting means which receives an emergent light beam which emerges from said electro-optic material for detecting voltages at said specific positions of the object to be measured based on changes in polarization of said emergent light beam caused by changes in said refractive index of said electro-optic material.

16. A voltage detecting device as claimed in claim 15, in which said optical means comprises a micro-lens array for dividing said light beam into said plurality of incident rays of light arranged in a lattice pattern.

17. A voltage detecting device as claimed in claim 15, in which said optical means comprises a micro-lens array and a plate-shaped mask disposed over said micro-lens array for dividing said light beam into said plurality of incident rays of light arranged in said predetermined pattern.

18. A voltage detecting device as claimed in claim 15, in which said optical means includes a holographic lens for dividing said light beam into said plurality of incident rays of light arranged in said predetermined pattern.

19. A voltage detecting device as claimed in claim 15, in which said optical means includes a spatial light modulator for dividing said light beam into said plurality of incident rays of light arranged in said predetermined pattern corresponding to an input image thereof.

20. A voltage detecting device as claimed in claim 15, in which said light source means is a pulse light source and said detecting means is a two-dimensional detector including photo detector array in which voltages at said specific positions of the object to be measured is detected by sampling.

21. A voltage detecting device as claimed in claim 15, in which said light source is one of a pulse light source and a CW light source and said detecting means is a high-speed response detector.

22. A voltage detecting device as claimed in claim 21, in which said high-speed response detector is a streak camera.

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FIG. 1

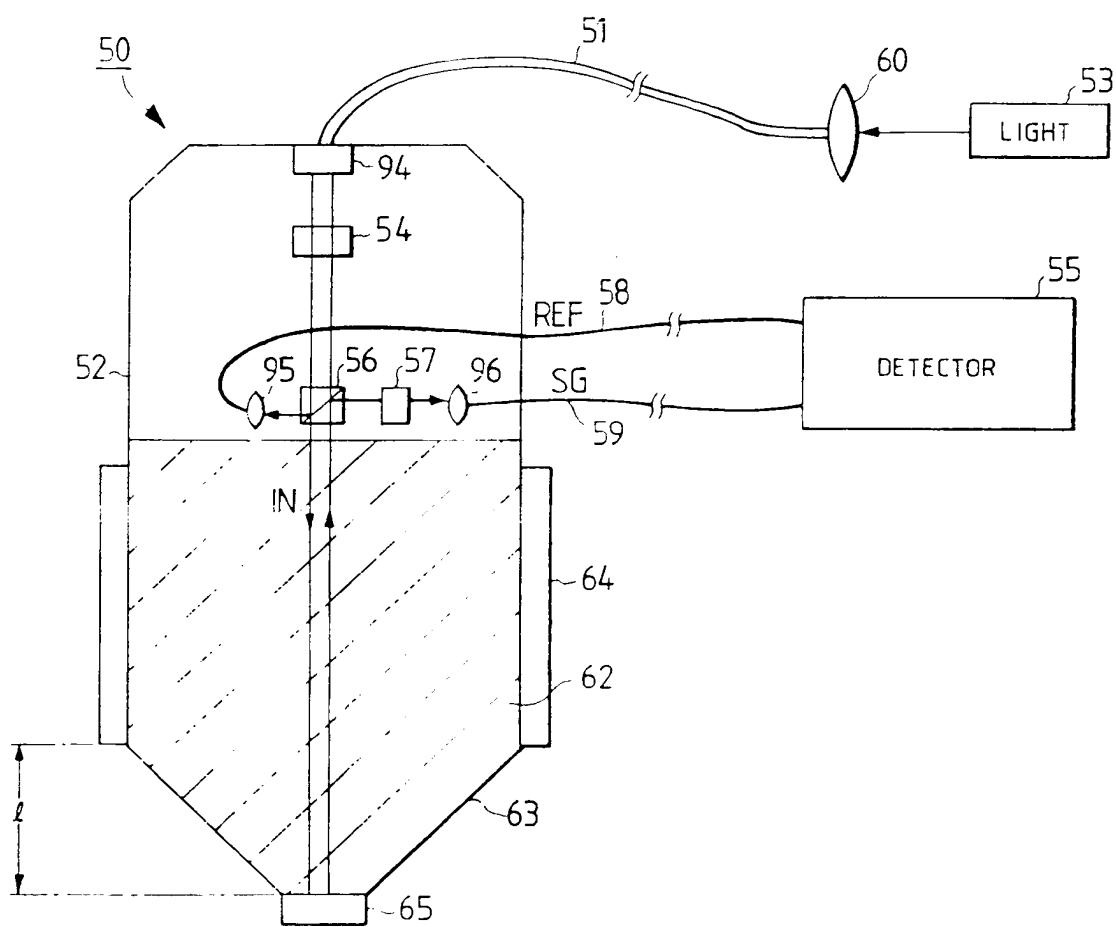


FIG. 2

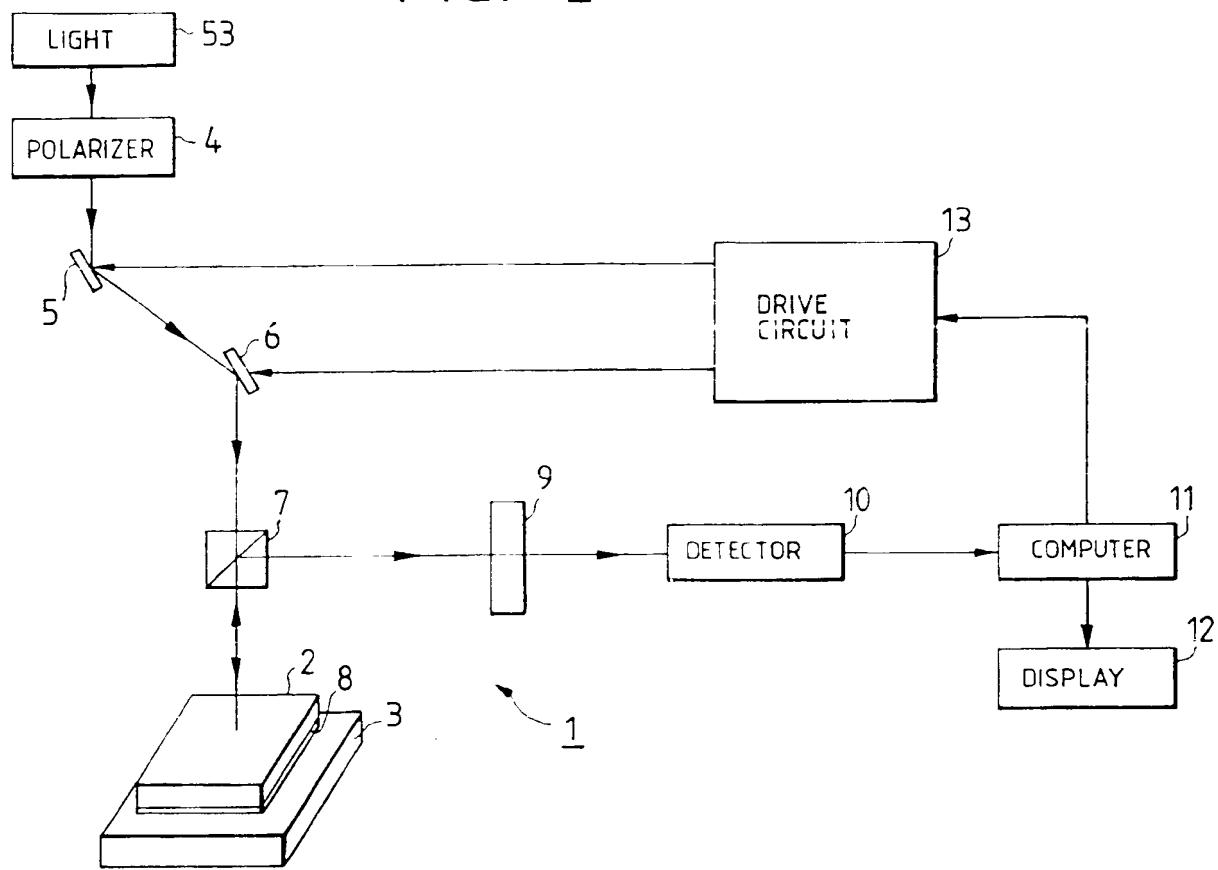


FIG. 3

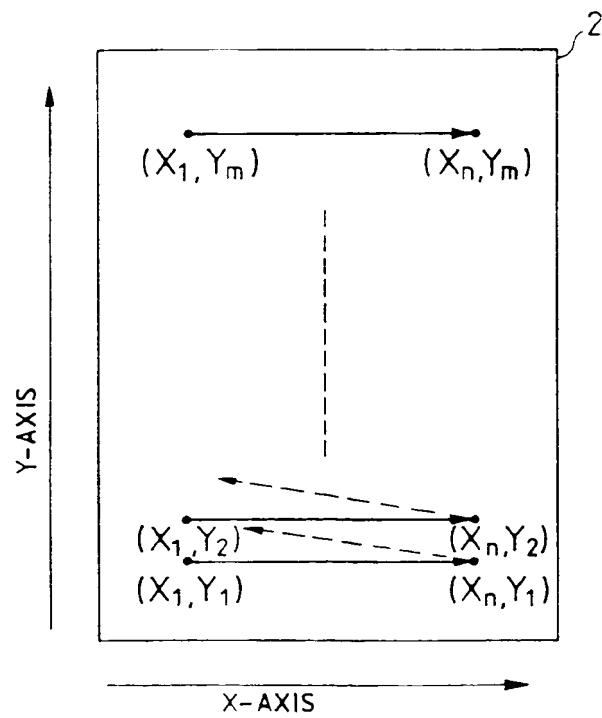


FIG. 4

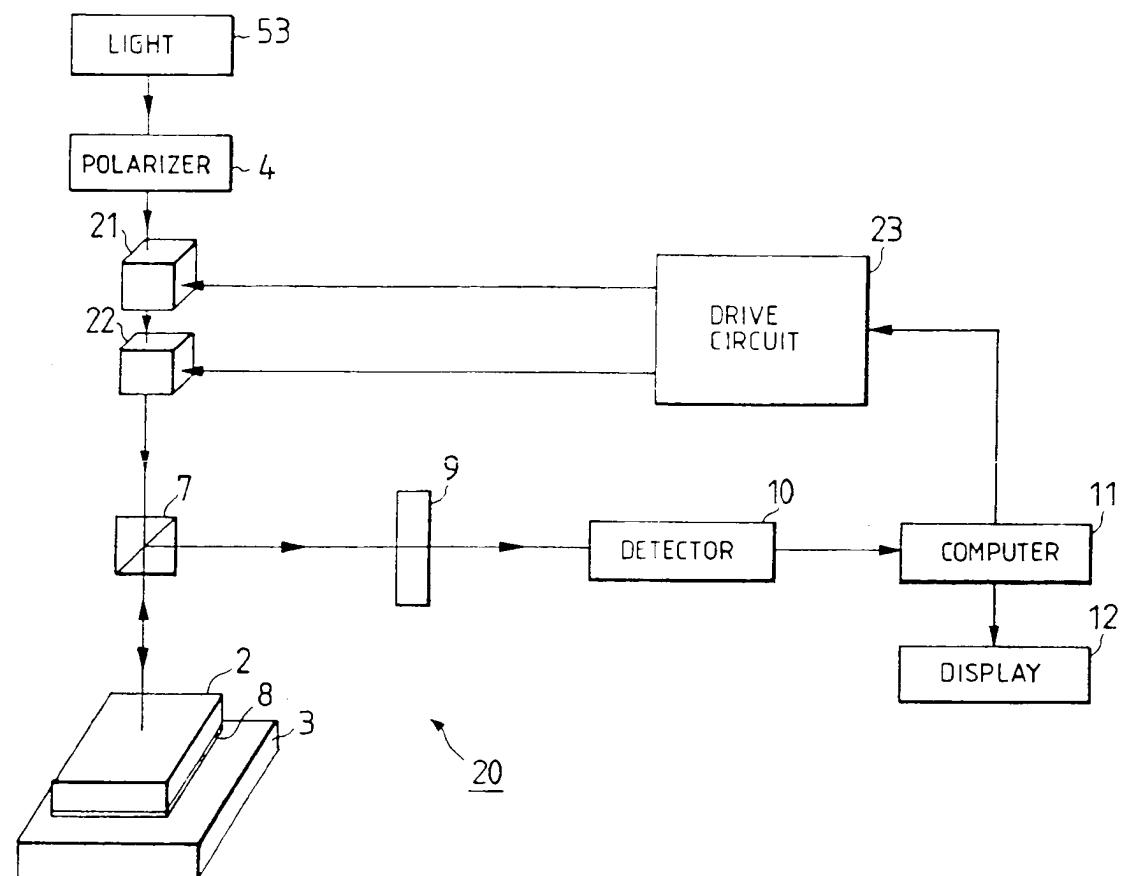


FIG. 5

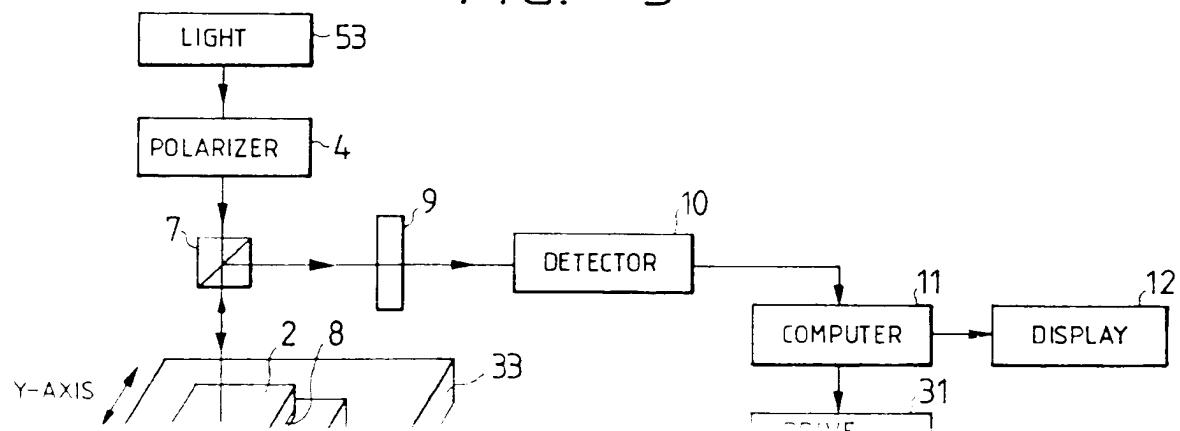


FIG. 6

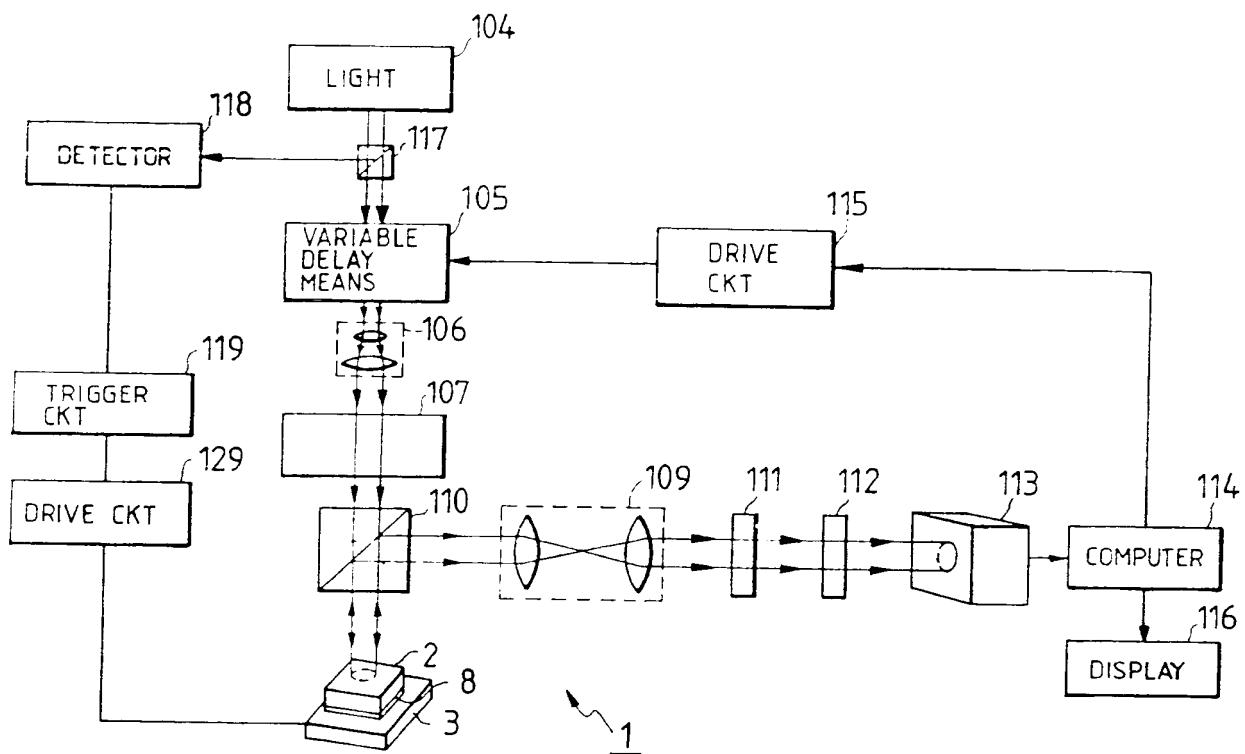


FIG. 7

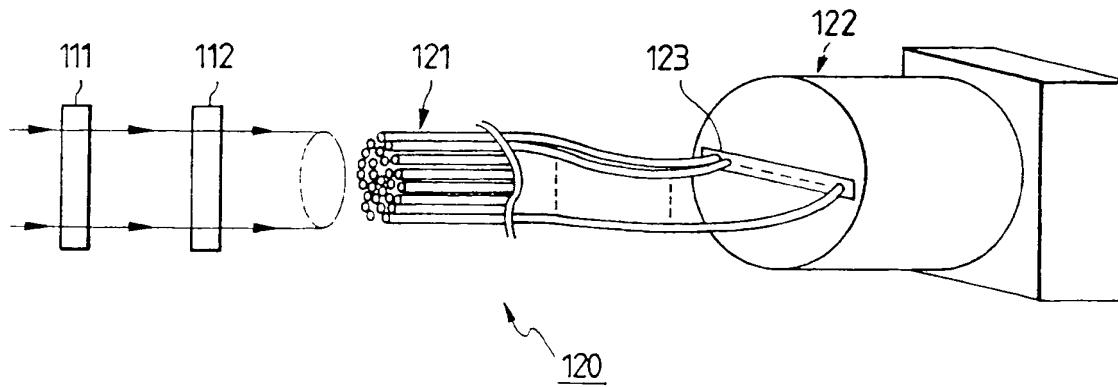


FIG. 8

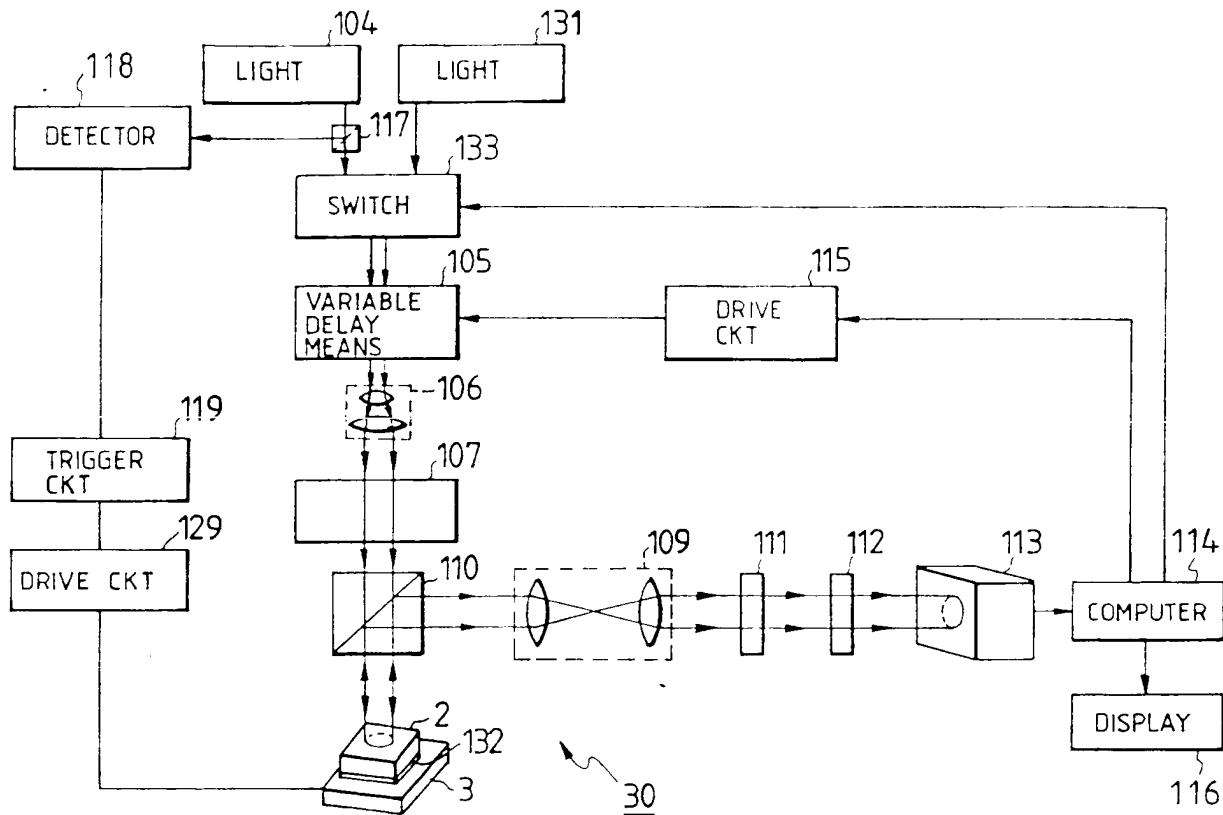


FIG. 9(a)

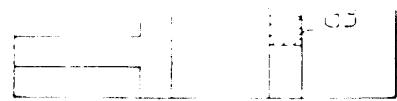
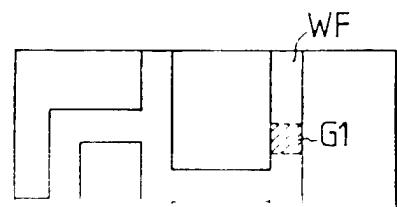


FIG. 9(b)

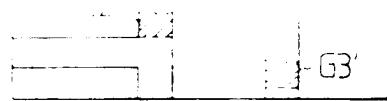
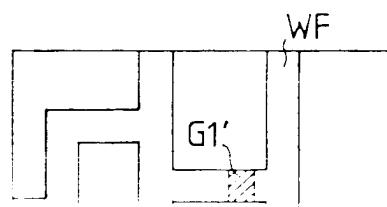


FIG. 10

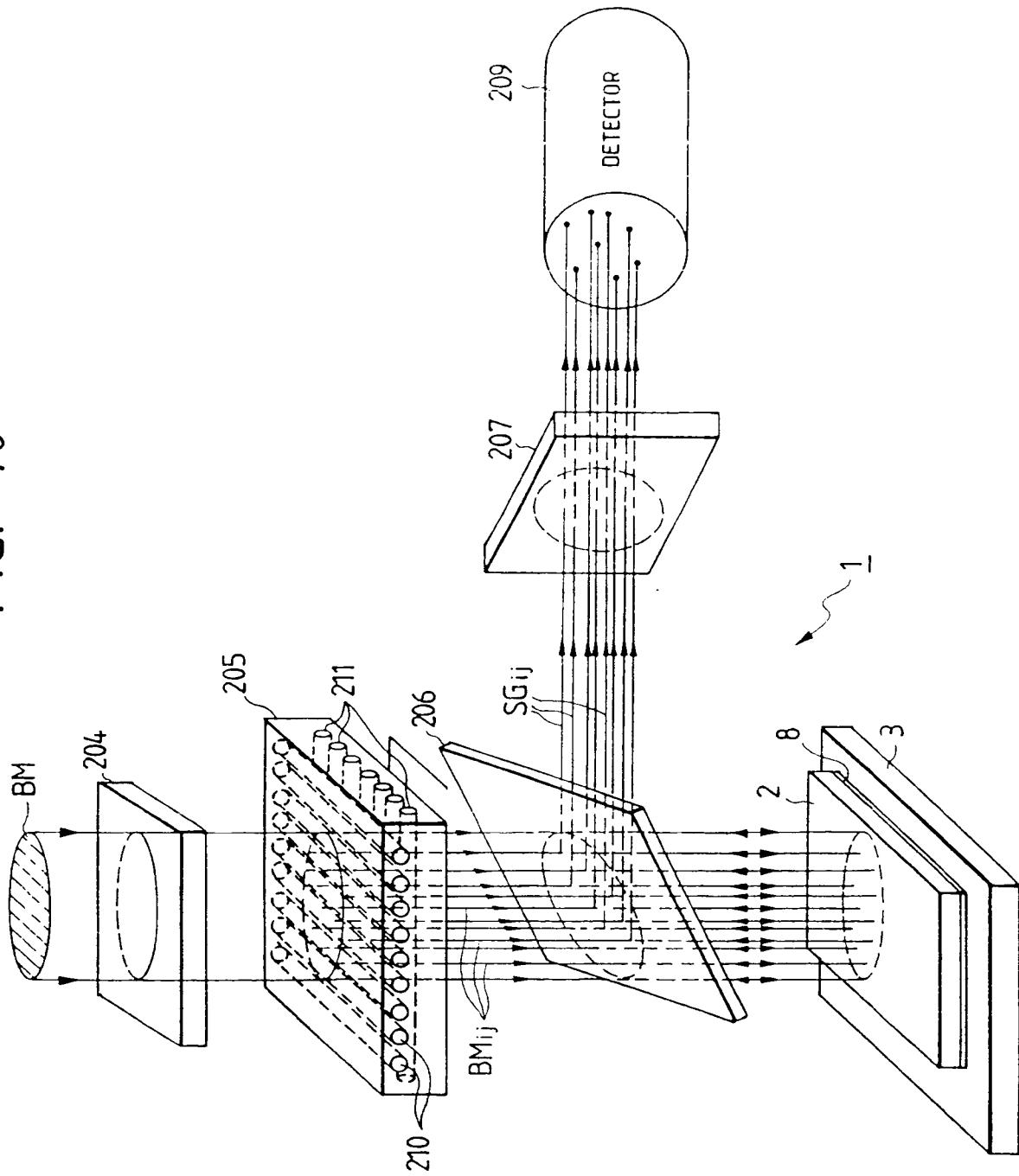


FIG. 11

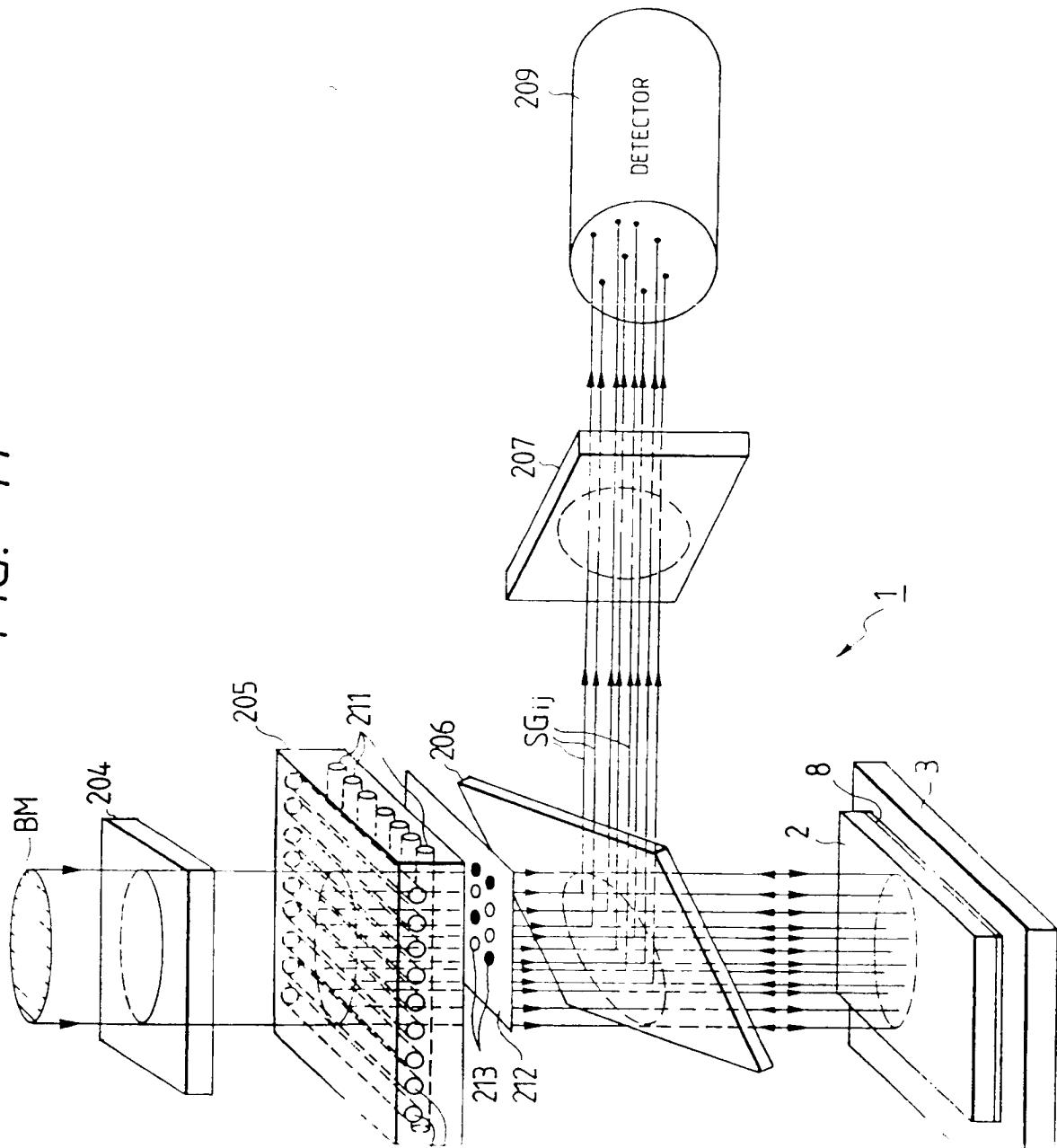


FIG. 12

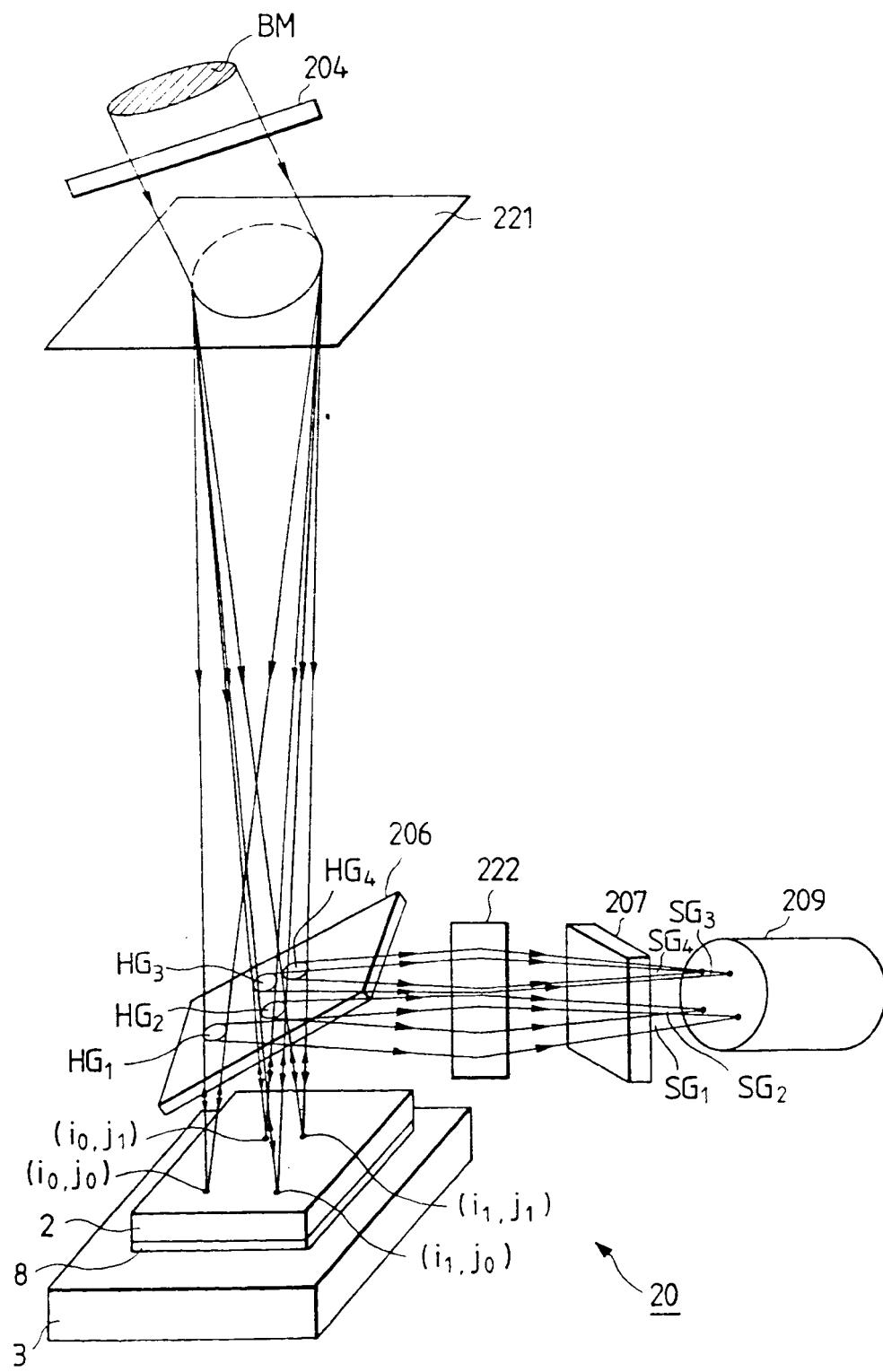
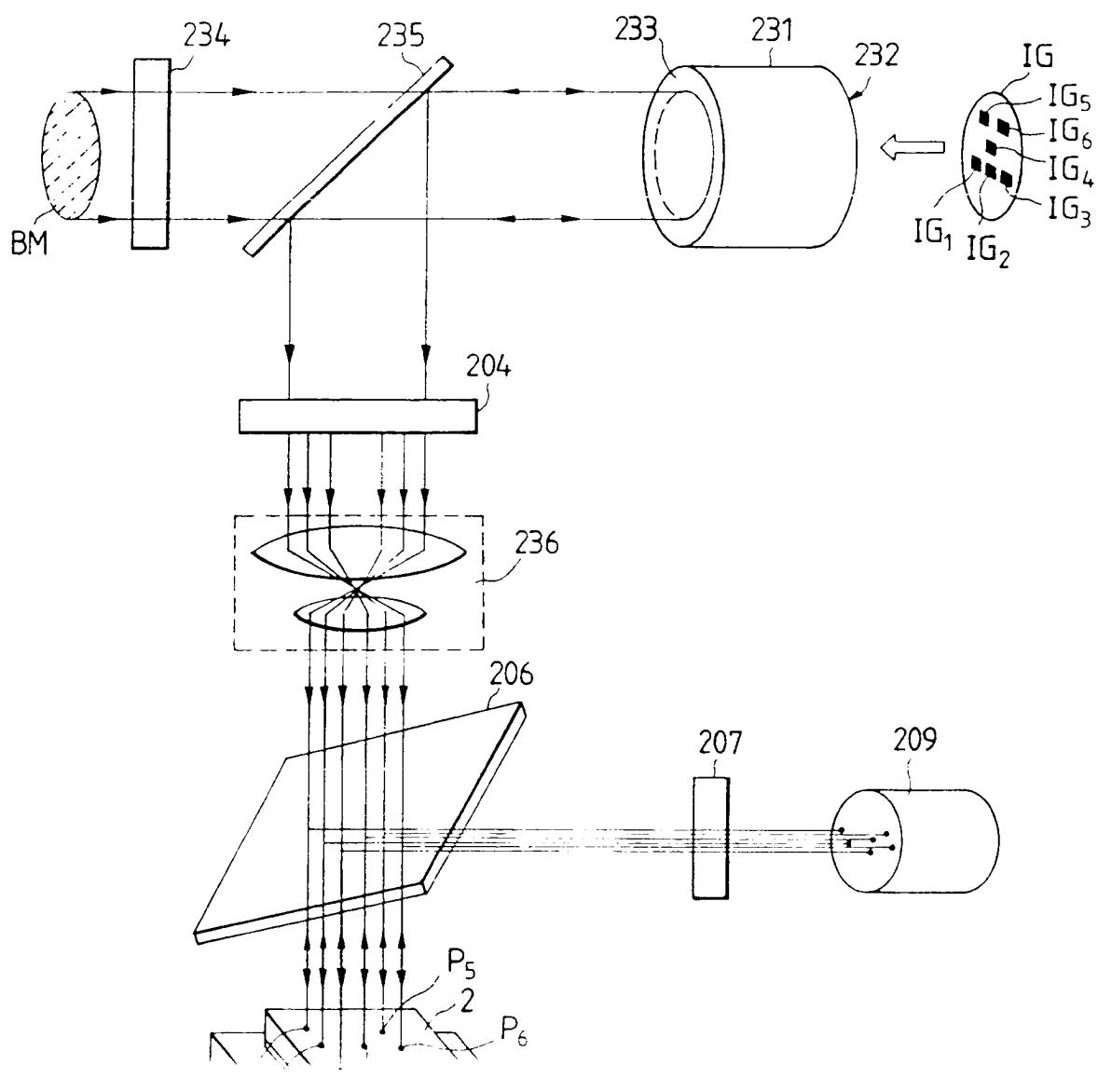
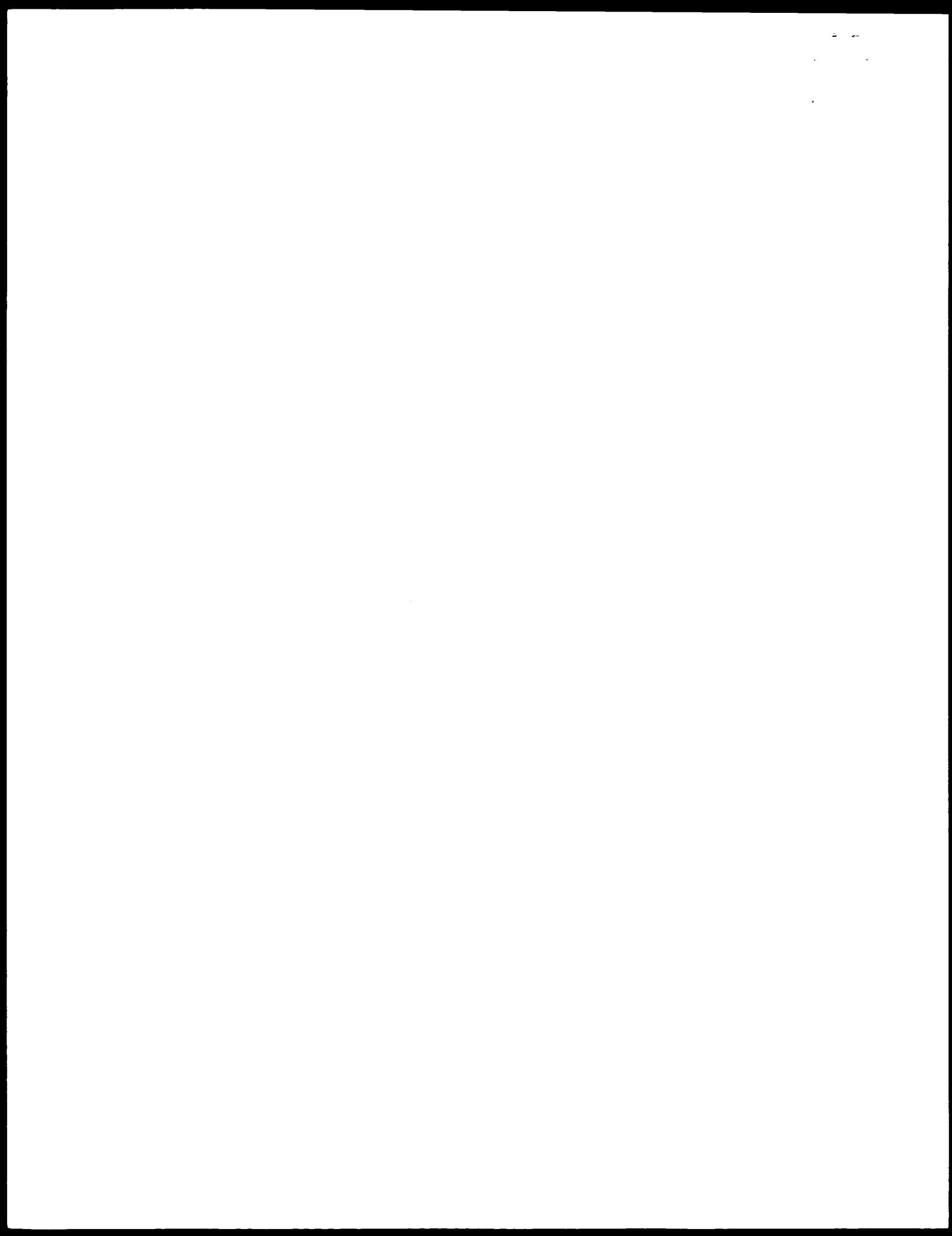


FIG. 13



P₄ P₅





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European Patent Office
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(1) Publication number:

0 299 432
A3

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: 88111142.1

(11) Int. Cl. 5 G01R 15/07, G01R 31/28,
G01R 1/067

(22) Date of filing: 12.07.88

(30) Priority: 13.07.87 JP 174534/87
13.07.87 JP 174535/87
13.07.87 JP 174536/87

(43) Date of publication of application:
18.01.89 Bulletin 89/03

(84) Designated Contracting States:
DE GB

(86) Date of deferred publication of the search report:
06.06.90 Bulletin 90/23

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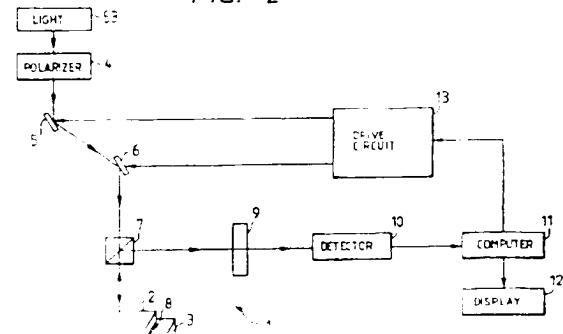
(54) A voltage detecting device.

(57) A voltage detecting device for detecting voltages in an object under test including an electro-optic material covering a plurality of parts of the object under test; the refractive index of the electro-optic material being variable according to an applied voltage. A light source emits light through the electro-optic material toward the object under test and a detecting device receives an emergent light beam reflected from within the electro-optic material in order to detect voltages in the object. Further, a scanning device automatically scans the object under test with the light beam in order to detect

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FIG. 2





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DOCUMENTS CONSIDERED TO BE RELEVANT		Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Category	Citation of document with indication, where appropriate, of relevant passages		
Y	US-A-4618819 (G.MOUROU ET AL.) * column 3, line 5 - column 3, line 28; claim 1; figures 2, 3 *	1-5, 7, 12	G01R15/07 G01R31/28 G01R1/067
Y	PATENT ABSTRACTS OF JAPAN vol. 6, no. 247 (E-146)(1125) 7 December 1982, & JP-A-57 147247 (HITACHI) 11 September 1982, * the whole document *	1-5, 7, 12	
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 41 (P-106)(919) 13 March 1982, & JP-A-56 157872 (SUMITOMO) 5 December 1981, * the whole document *	1-5, 7, 12	
A	ELECTRONICS LETTERS. vol. 22, no. 17, August 1986, ENAGE GB pages 918 - 919; J.Nees et.al.: "Noncontact electro-optic sampling with a GaAs injection laser" * pages 918 - 919 *	1-5	
		TECHNICAL FIELDS SEARCHED (Int. Cl.4)	
		G01R1/067 G01R15/07 G01R31/28 G02F1/03	
The present search report has been drawn up for all claims			
2	Place of search BERLIN	Date of completion of the search 16 MARCH 1990	Examiner LEMMERICH J.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			